

**CURRENT and TEMPERATURE DATA
FROM INSTRUMENT MOORINGS in FRAM STRAIT
DURING MIZEX 83**

by Kenneth Hunkins

**TECHNICAL REPORT
LDGO-84-1**

Department of the Navy
Office of Naval Research
Contract CU-002-97201

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ABSTRACT

The purpose of the MIZEX 83 field program in mesoscale oceanography was to monitor mesoscale variability in Fram Strait. An array of instruments was moored in open water near the center of Fram Strait to assist in accomplishing this goal. Current, temperature and pressure measurements from this array are plotted against time. Simple statistics and power spectra for these data are also presented.

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ACKNOWLEDGEMENTS

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Werner Tiemann, Dennis Camp, Barry Allen and Rich Cember assisted with data reduction. Tom Manley wrote a number of the computer programs used in reduction.

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Introduction

An array of moored oceanographic recording instruments was placed in Fram Strait at the beginning of the Marginal Ice Zone Experiment in 1983 (MIZEX 83) and recovered at the end of the experiment. The array was situated near the center of the Strait on the sill separating the Arctic Ocean from the Greenland Sea (Figure 1). Three moorings were arranged in a triangle with the fourth mooring at the center of the triangle. Nominal spacing was 10 km, a distance chosen to be close to the Rossby radius of deformation in the region. The array was in open water east of the ice edge.

The objective was to monitor mesoscale oceanographic fluctuations in open water near the ice edge. An oceanographic front is generally associated with the ice edge and two extreme hypotheses might be postulated about mesoscale motion in the area. Such motions could be due to a spectral cascade of energy generated in boundary layers by the mean flow. In this case, spectra in the time domain would be expected to show a monotonic decrease in energy from low to high frequencies, representing a cascade of geostrophic turbulence. An alternate hypothesis would be that instability processes in the mean shear across the front favor the growth of certain discrete frequencies and wavenumbers. In this case the recordings would be expected to show one or more spectral peaks in the sub-inertial frequency range.

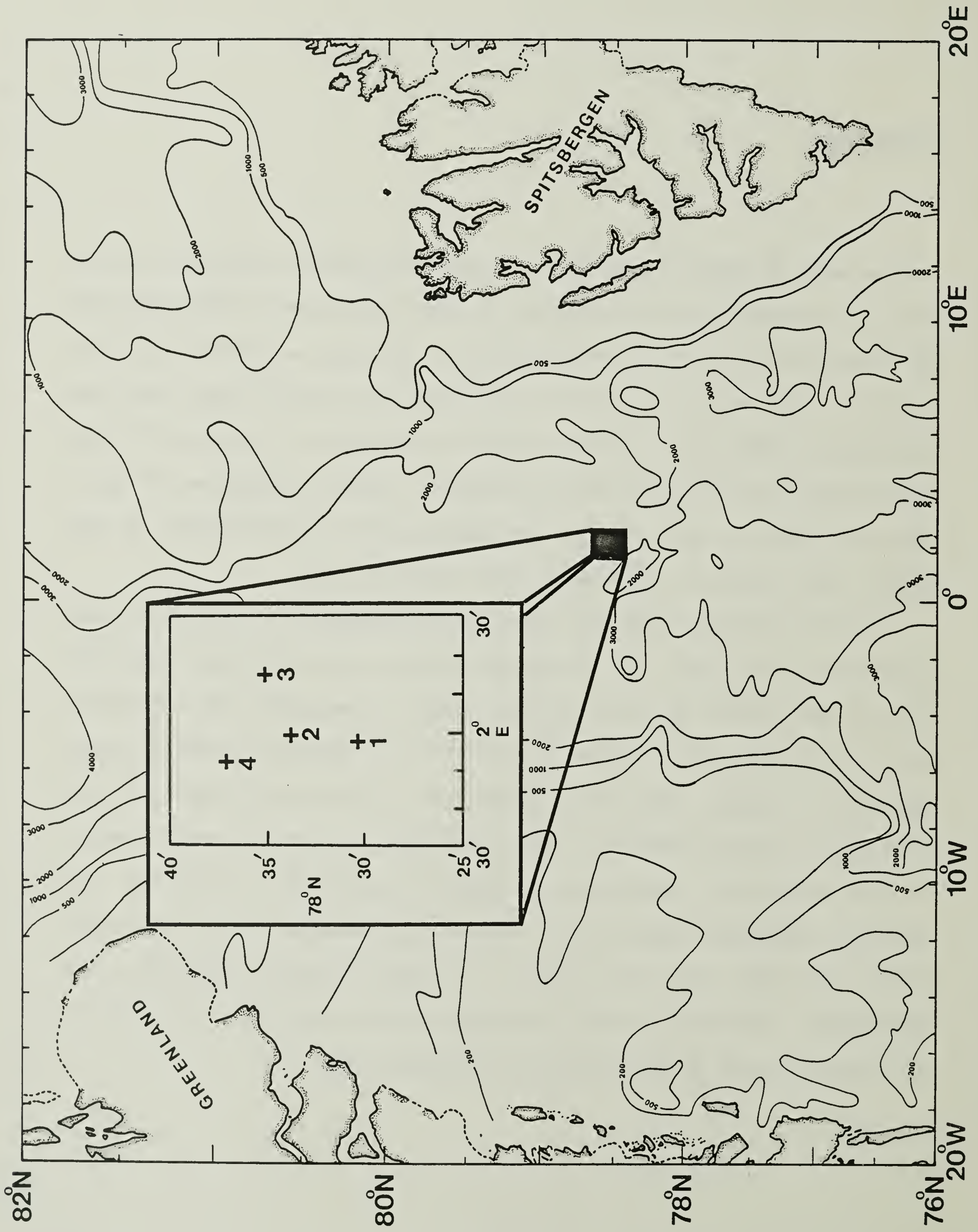


Figure 1 - Location of MIZEX 83 Mooring Array. (Bathymetry from Johannessen & Johannessen, 1983).

The MIZEX 83 Moorings

Four subsurface moorings were deployed in water depths of about 2,400 m on June 16 - 17, 1983 from M/V POLARBJORN in an array nominally centered at 78°30' N 002° E (Table 1). The array location was south of the Molloy Deep, where depths exceed 4,000 m, and north of a northwest-southeast trending ridge which rises to a depth of about 1,700 m. Bottom slopes were gentle in the area of the array. All of the moorings and instruments were retrieved 41 days later on July 27, 1983. One of the moorings was then redeployed to record over the next year. It will be retrieved during MIZEX 84.

Aanderaa RCM-5 current meters were used to record current speed and direction, as well as temperature and depth. Manufacturer's specifications for these instruments are:

| | |
|------------------------------|------------------------------|
| Temperature resolution | $\pm 0.01^{\circ} \text{ C}$ |
| Current speed accuracy | $\pm 2 \%$ of actual speed |
| Current direction resolution | $\pm 0.35^{\circ}$ |

All instruments were calibrated before the MIZEX 83 cruise. Although the instruments were equipped with conductivity sensors, range settings were incorrect for this region and no salinity data were obtained. Current meters were suspended at nominal depths of 50 and 150 m below the surface on all four moorings. Additional instruments were suspended at depths of 1,000 below the surface and 100 m above the bottom. Data were sampled every 10 minutes.

The magnetic recording tape failed to transport on four of the twelve instruments deployed. The malfunction was later found to be caused by excessive use of tape head cleaner which did not entirely evaporate before the tape was mounted. This resulted in adhesion of tape to the tape head.

Table 1

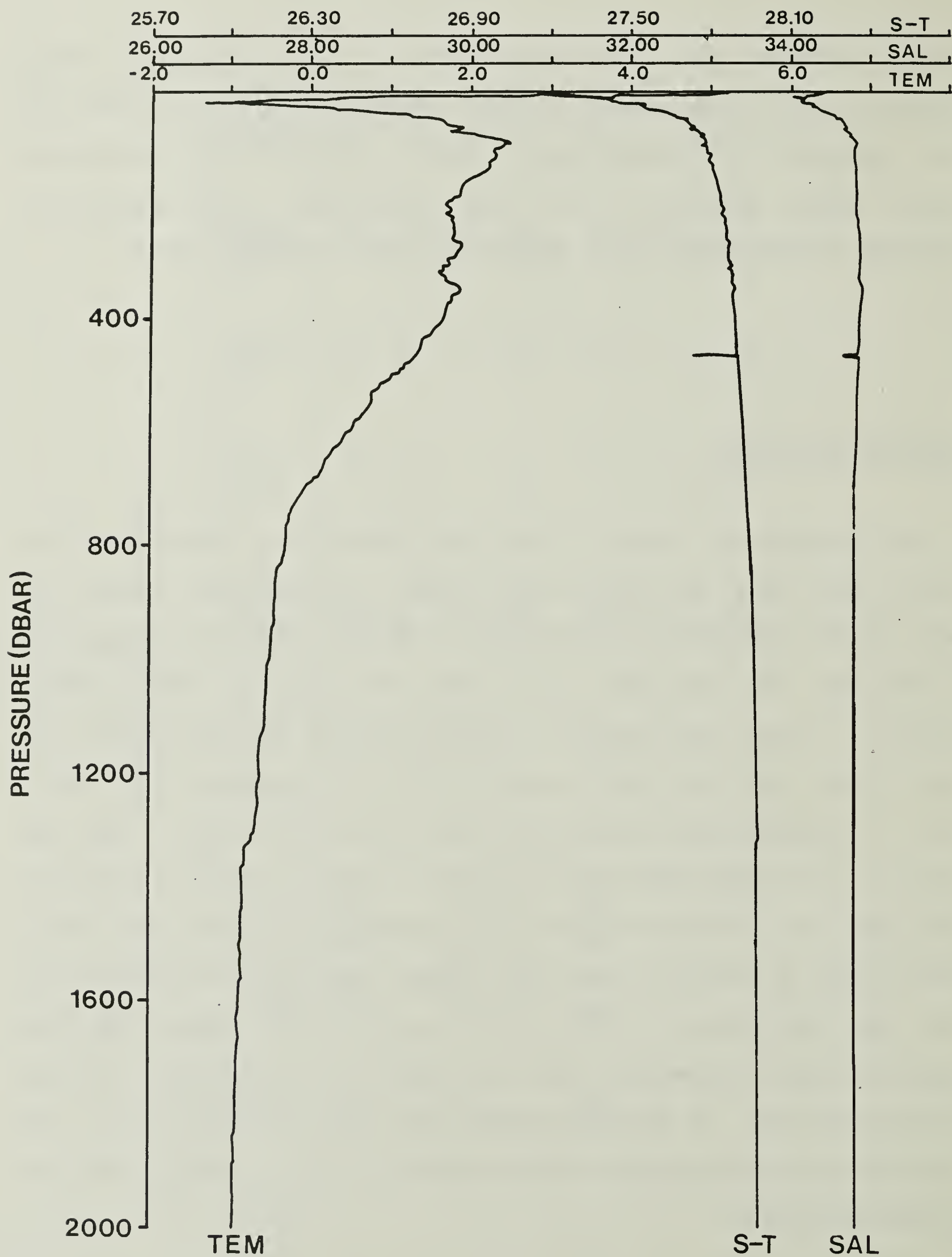
MOORING LOCATIONS and DEPTHS

| Mooring Number | Ocean Depth (m) | Latitude N deg min | Longitude E deg min | Aanderaa S.N. | Minimum Depth (m) | Mean Depth (m) | Maximum Depth (m) | Record Length (days) |
|-------------------|-----------------------|-----------------------|------------------------|------------------|-------------------------|----------------------|-------------------------|----------------------------|
| 1 | 2340 | 78 30.42 | 1 57.66 | 5786 | 52 | 55 | 77 | 26.14 |
| | | | | 5461 | 151 | 154 | 179 | 33.63 |
| 2 | 2347 | 78 33.78 | 1 58.80 | 5378 | 61 | 63 | 92 | 41.24 |
| | | | | 6538 | 1015 | 1018 | 1047 | 41.15 |
| 4 | 2439 | 78 36.06 | 1 52.02 | 5785 | 55 | 59 | 106 | 40.78 |
| | | | | 5760 | 158 | 161 | 207 | 40.75 |
| | | | | 6536 | 1014 | 1017 | 1059 | 40.76 |
| | | | | 5889 | 2296 | 2304 | 2309 | 40.74 |

Another instrument was accidentally fouled in the mooring cable during launching so that it was unable to swivel. Temperature data are available for that instrument, but current data are invalid. On three other instruments digital noise, apparently due to poor functioning of the digitization mechanism in these three meters, reduced the length of useable record.

Oceanographic Setting

The moorings were situated in open water 50 km east of the ice edge which trends nearly north and south in this region. An oceanographic profile was made from M/V POLARBJORN by the University of Bergen Oceanographic Group, with a Neil-Brown CTD instrument, just before the moorings were retrieved (Figure 2). Sigma-t was about 27.2 at the surface and increased rapidly with depth in the upper 100 meters so that at 150 m, it was about 27.8. Below 100 m it increased slowly and was still less than 28.0 at 2,000 m. There was a thin layer of warm surface water at about 5° C which extended to a depth of only about 10 m. A thin cold layer at 25 m separated the surface layer from a warmer layer of Atlantic origin with maximum temperatures exceeding 2° C. This layer extended to a depth of 700 m, below which temperatures were negative, closely approaching -1.00° C at 2,000 m. At the surface, salinity was about 34.0 ppt. It increased rapidly with depth in the first 100 m, then increased only slowly at greater depths approaching a value slightly less than 35.0 ppt at 2,000 m.



PROFILE:
 STA: 319 / POS:78.500°N 2.598°E / TIME:83-7-25:2.47

Figure 2 - CTD Station 319, 78.5°N, 2.6°E; 25 July 83.
 (Redrawn from Johannessen and Johannessen, 1983).

Mean Currents and Temperatures

Mean values and standard deviations for temperature and current components are presented in Table 2. The shallowest instruments, nominal depth of 50 m, had mean temperatures of 3.62, 2.51 and 2.56° C. The 3.62° C value is from a shorter record and thus cannot be compared directly with the other two means of 2.51 and 2.56° C which are satisfyingly close to each other in value. Their large standard deviations, ± 0.36 and $\pm 0.63^{\circ}\text{C}$ reflect the fact that these instruments are located in a thermocline, so that any vertical water motions produce large recorded temperature variations.

The two instruments at the 150-m level recorded mean temperatures of 1.67 and 1.62° C, again relatively close in value as are also the two means of -0.77 and -0.74° C at the 1,000-m level. There was only one record from 100 m above the bottom and the mean at that level was -1.00° C, quite close to the temperature at 2,000 m observed for the CTD profile. The standard deviation of $\pm 0.04^{\circ}\text{C}$ near the bottom indicates the constancy of temperature at that level and also gives some measure of the repeatability of the temperature measurements.

Mean currents at four levels in the water column from near the surface to near the bottom all have a southward component (Figure 3). Mean speeds are relatively high, ranging from 5.2 to 7.6 cm/s. Although there are shears between the different levels, it is perhaps the agreement rather than differences between these means that should be emphasized. The general similarity in speed and direction between the different levels suggests that the mean flow has a large barotropic component. The time series do show some long-period trends extending over several weeks, and means over longer periods

Table 2

MEAN VALUES and STANDARD DEVIATIONS
for TEMPERATURE and CURRENT

| Mooring Number | Instrument Depth (m) | Record Length (days) | \bar{T} (°C) | \bar{u} (cm/s) | \bar{v} (cm/s) |
|-------------------|----------------------------|----------------------------|-------------------|---------------------|---------------------|
| 1 | 52 | 26 | 3.62 ±0.56 | -1.7 ±8.2 | 0.4 ±9.4 |
| | 151 | 29 | 1.67 ±0.30 | 1.6 ±5.3 | -5.0 ±7.3 |
| 2 | 61 | 41 | 2.51 ±0.36 | | |
| | 1015 | 41 | -0.77 ±0.08 | 1.1 ±2.5 | -4.4 ±4.2 |
| 4 | 55 | 41 | 2.56 ±0.63 | -2.0 ±6.6 | -7.5 ±8.2 |
| | 158 | 30 | 1.62 ±0.40 | -2.0 ±5.8 | -6.5 ±7.3 |
| | 1014 | 41 | -0.74 ±0.08 | 0.5 ±2.4 | -5.2 ±3.8 |
| | 2296 | 41 | -1.00 ±0.04 | 1.2 ±3.0 | -7.5 ±3.9 |

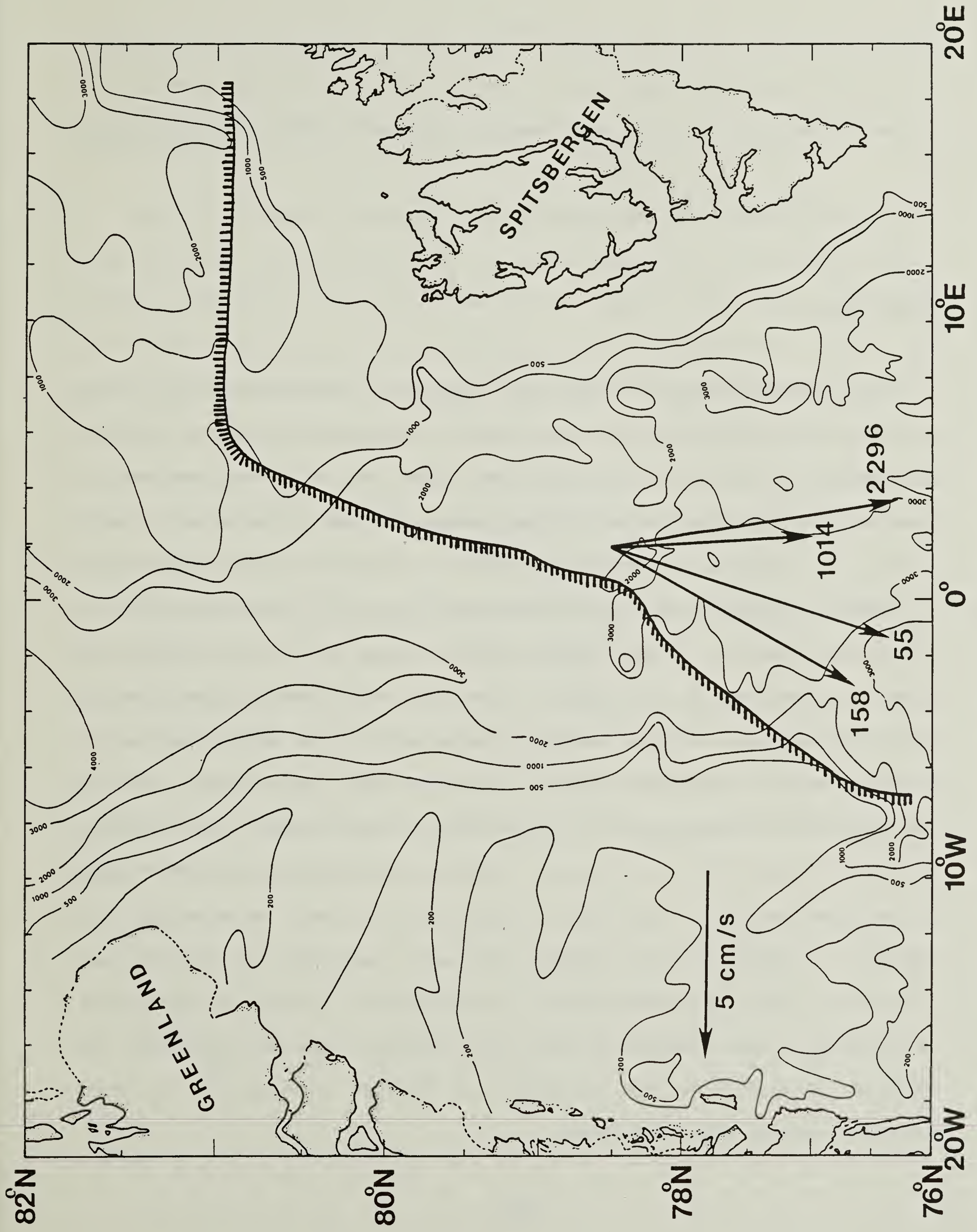


Figure 3 - Mean current vectors at Mooring 4. Depths in meters, 41-day means except for the 158-m record which is a 30-day mean

might have shown different results. The results do indicate that there must have been a large northward flow in another part of the Strait during this period to compensate for the large observed southward transport.

Time Series

The data are presented as plots of temperature, eastward velocity (U) and northward velocity (V) for each instrument. Instrument depth is also plotted. The instruments were all calibrated just before the cruise and the results have been reduced using the corrections indicated by the calibrations. A correction for a magnetic declination of 12.3° W was made to current direction.

Visual examination of the records shows fluctuations of semidiurnal tidal period, as well as longer period events lasting several days which are probably meteorological in origin. A prominent cold feature appears on the shallow temperature record at mooring 4 during July 9 - 10, 1983. Temperature at the 55 m level dropped by nearly 4° C in a few hours and continued cold for two days before returning to its normal level of about $2\frac{1}{2}^\circ$ C in as short a time as it took to drop. The feature is evident but attenuated at 158 m depth on the same mooring. There were no significant currents accompanying this feature. It appears to be a shallow cold water mass which was advected past the array. There were sharp drops in temperature on the shallow instruments at moorings 1 and 2 during the same time period as the more prominent one appeared on mooring 4, but the events on moorings 1 and 2 were of short duration, lasting only a few hours.

Power Spectra

Spectra of kinetic energy for the orthogonal current components generally show an energy decline from lowest to highest frequencies with prominent tidal peaks at semidiurnal and diurnal frequencies. Although some peaks are present at sub-tidal frequencies which are significant at the 95% level, they do not appear consistently on all records. The data thus seem to favor the geostrophic turbulence hypothesis referred to in the introduction. No prominent and consistent peaks of eddy energy are evident. Thus the spectra concur with visual examination of the time series which showed only a single shallow cold eddy in the 40-day period.

Spectral peaks at the semidiurnal peaks, M_2 and S_2 , appear in all spectra with energies generally higher in the north component. This tendency for alignment of tidal motion with the axis of Fram Strait is even more pronounced in the diurnal than in the semidiurnal component. In most of the spectra, the diurnal peak for the north component is only slightly less than the semidiurnal peak. However, the diurnal peak for the east component is small and not even evident in many of the spectra.

REFERENCES

Johannessen, J.A. and O.M. Johannessen, A CTD report from Marginal Ice Zone Experiment (MIZEX) in the Fram Strait region in June - August 1983, Vol. II. Geophysical Institute, Division A; University of Bergen, Bergen, Norway, 5 October 1983.

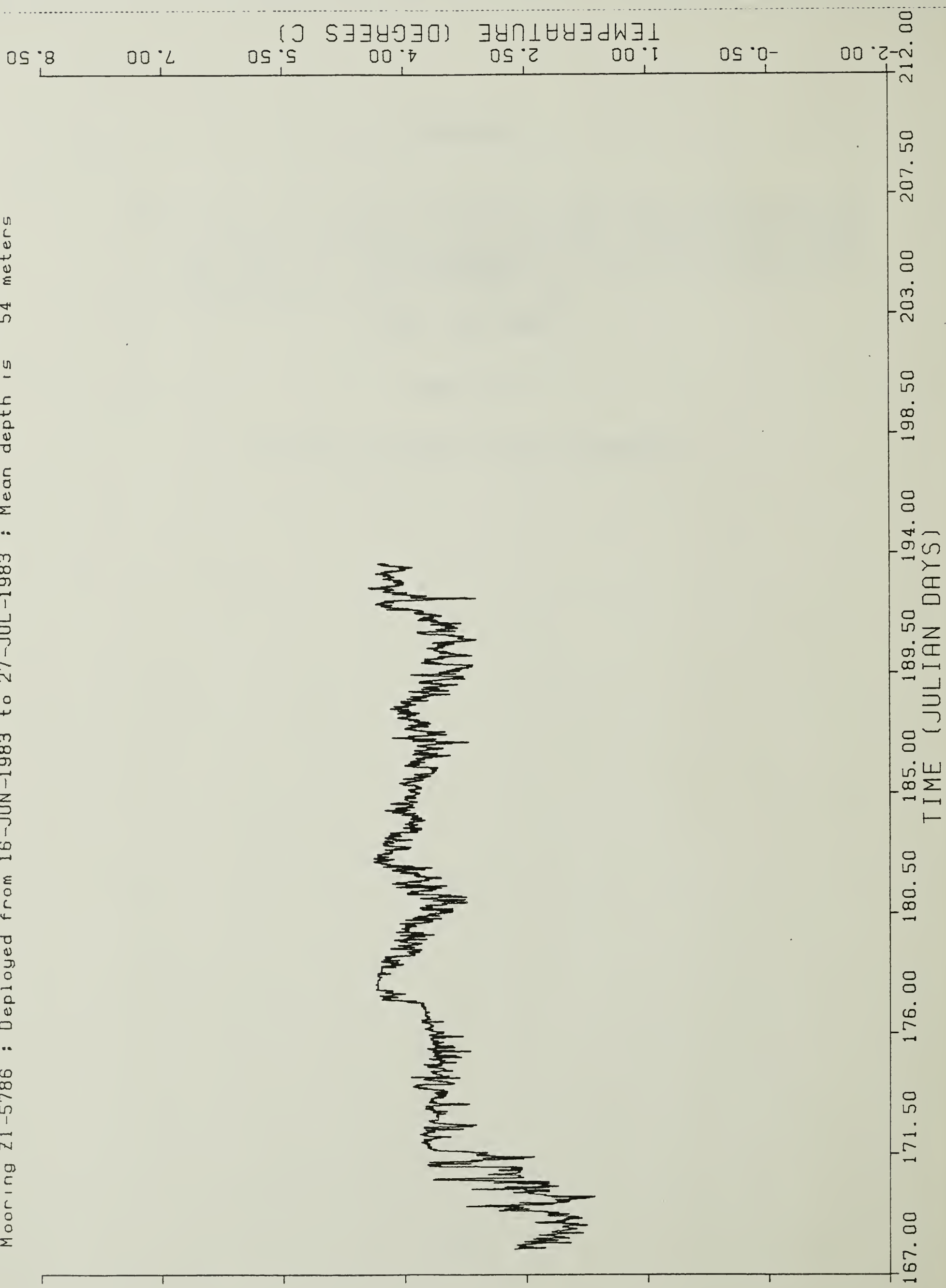
MOORING 1

RCM-5 No. 5786

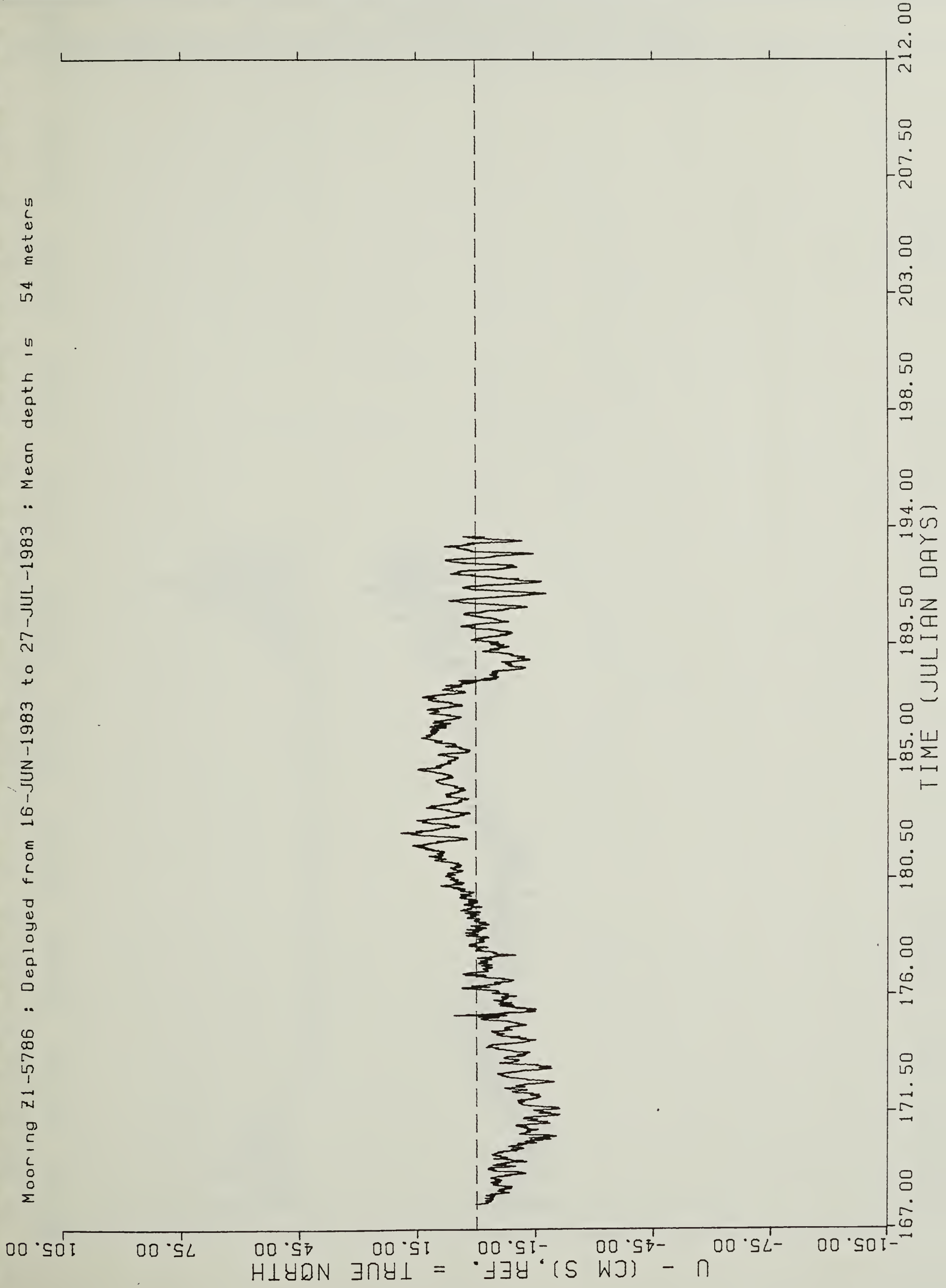
52 m Depth

Temperature, Current Components and Depth

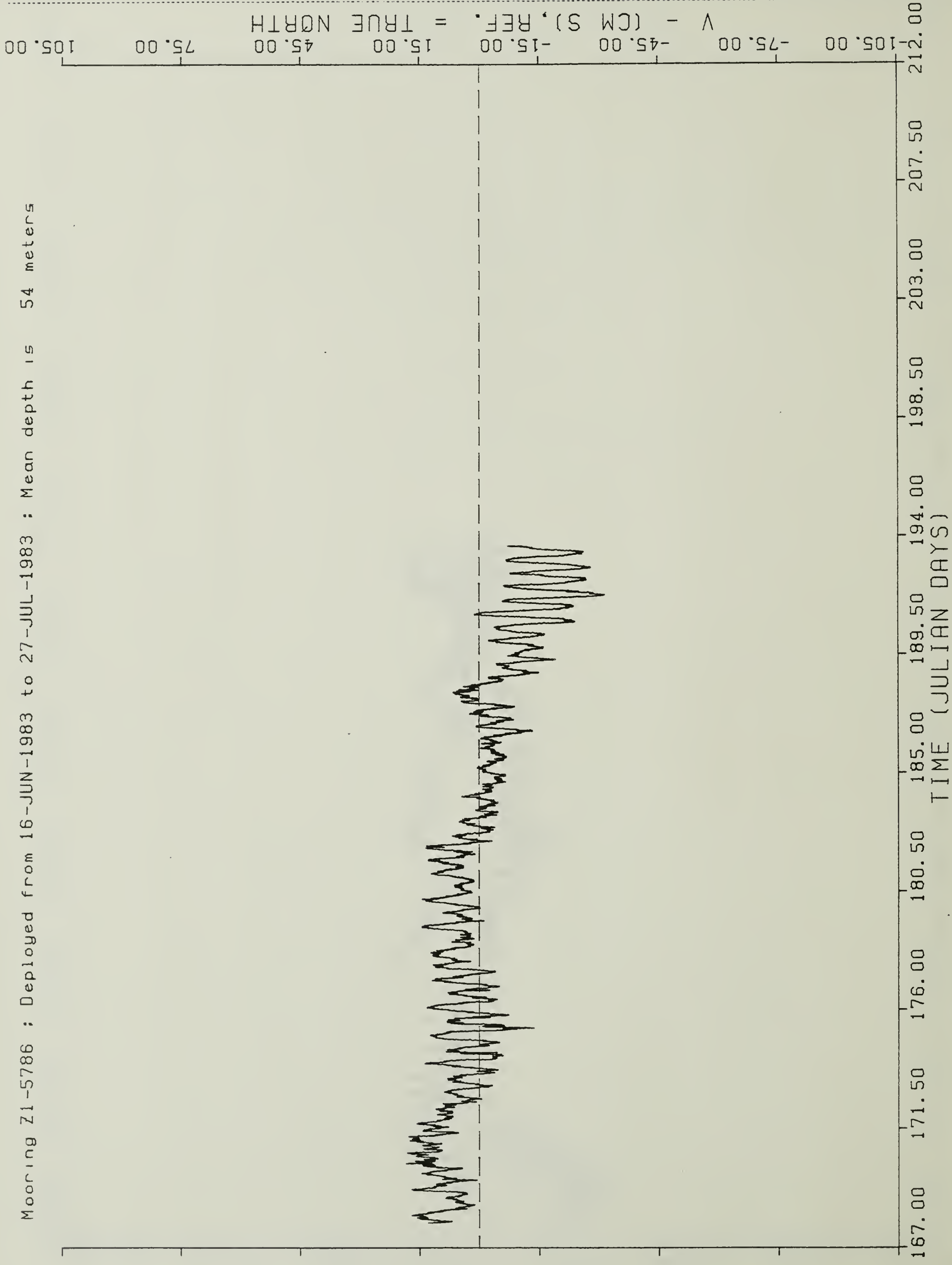
Mooring Z1-5786 : Deployed from 16-JUN-1983 to 27-JUL-1983 : Mean depth is 54 meters



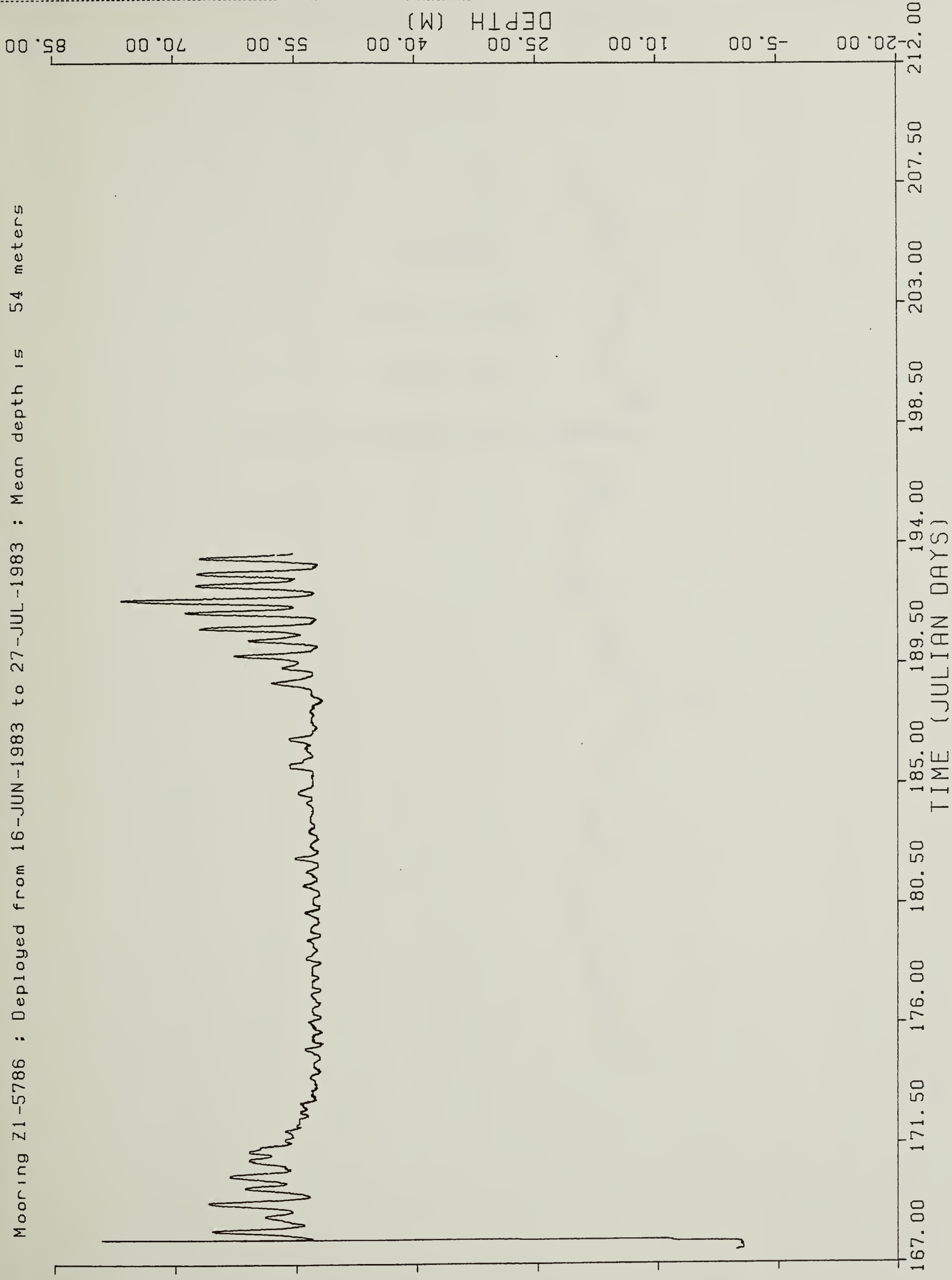
Mooring Z1-5786 : Deployed from 16-JUN-1983 to 27-JUL-1983 : Mean depth is 54 meters



Mooring Z1-5786 : Deployed from 16-JUN-1983 to 27-JUL-1983 : Mean depth is 54 meters



Mooring Z1-5786 ; Deployed from 16-JUN-1983 to 27-JUL-1983 ; Mean depth is 54 meters



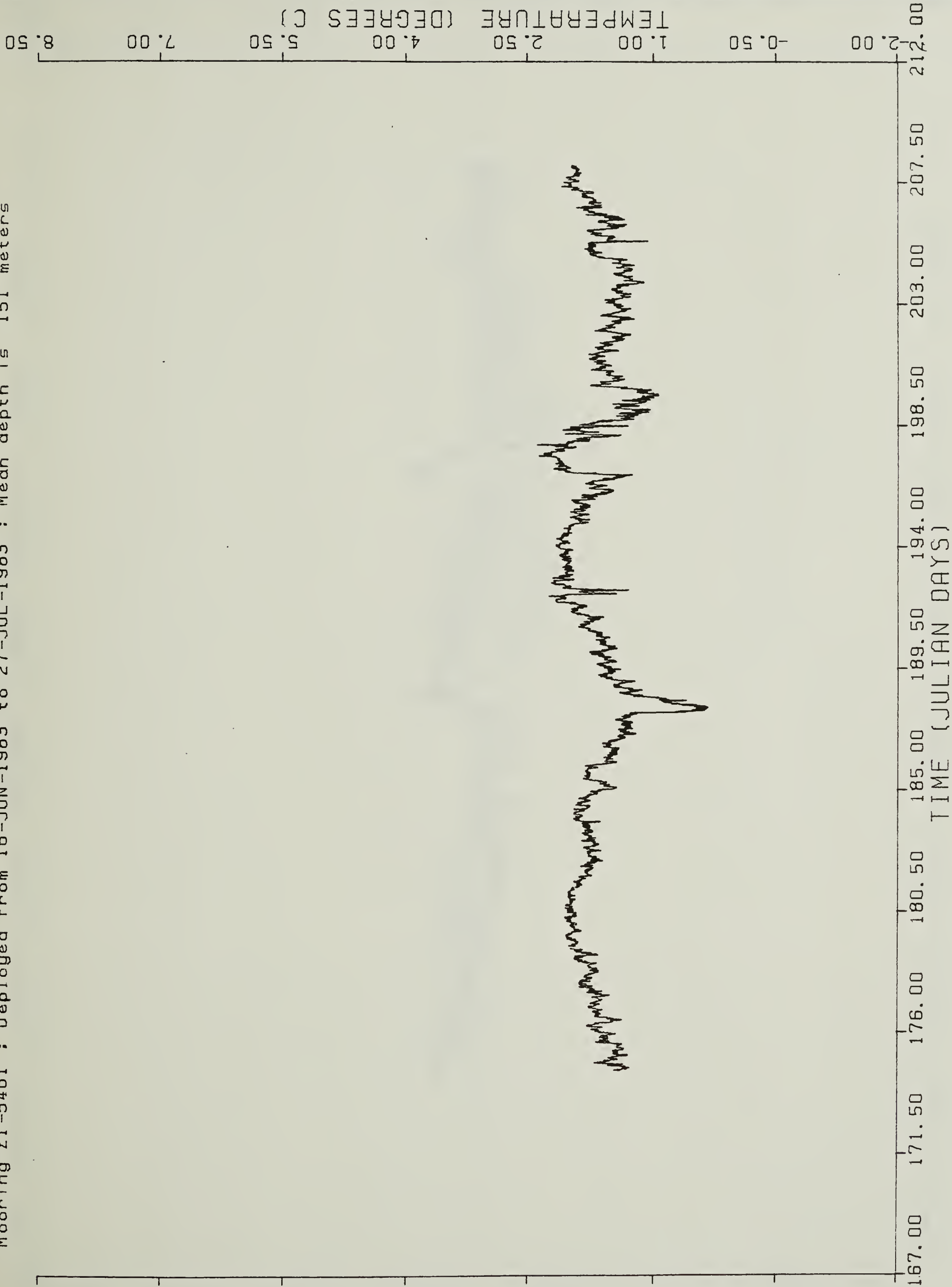
MOORING 1

RCM-5 No. 5461

151 m Depth

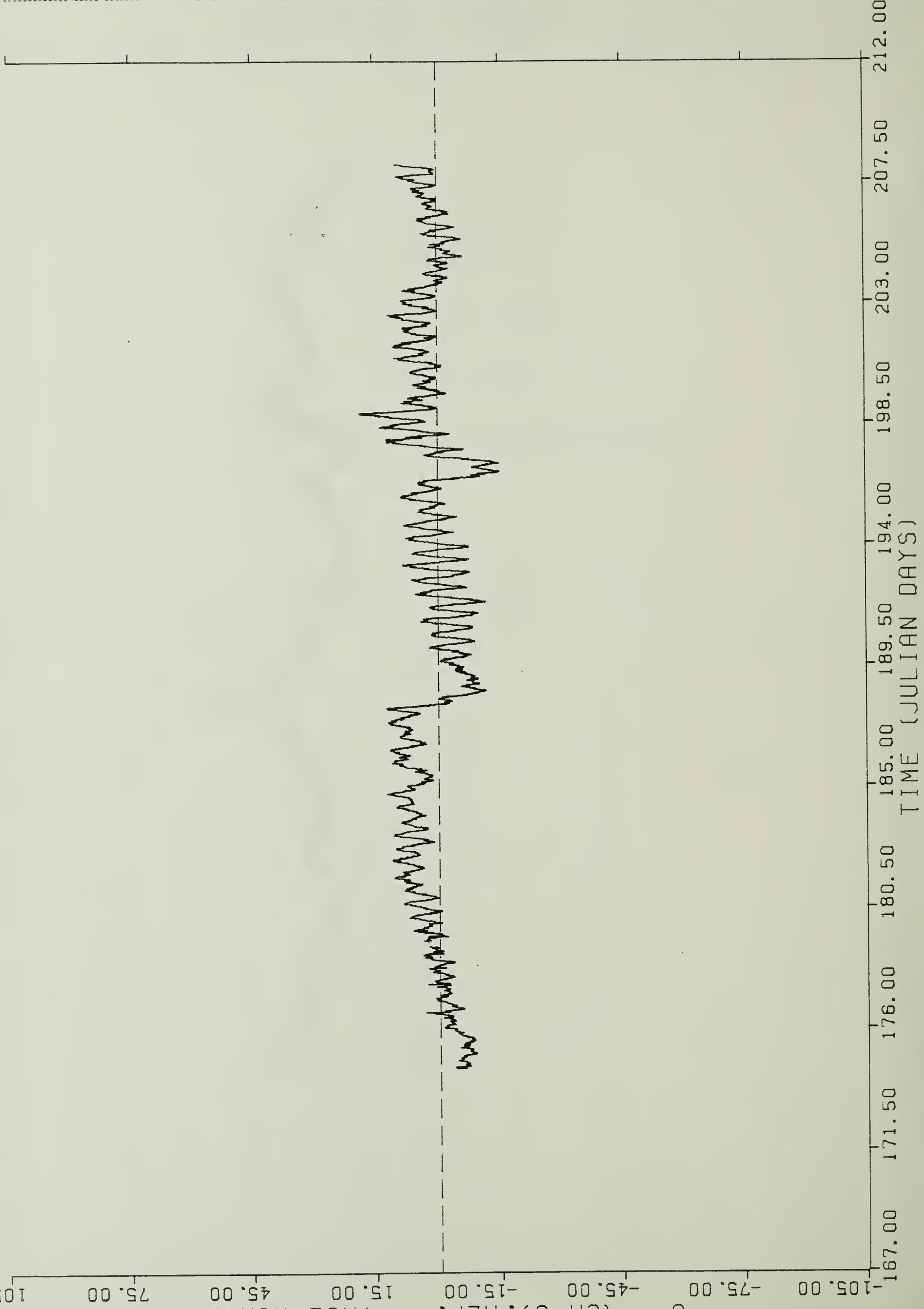
Temperature, Current Components and Depth

Mooring Z1-5461 : Deployed from 16-JUN-1983 to 27-JUL-1983 : Mean depth is 151 meters

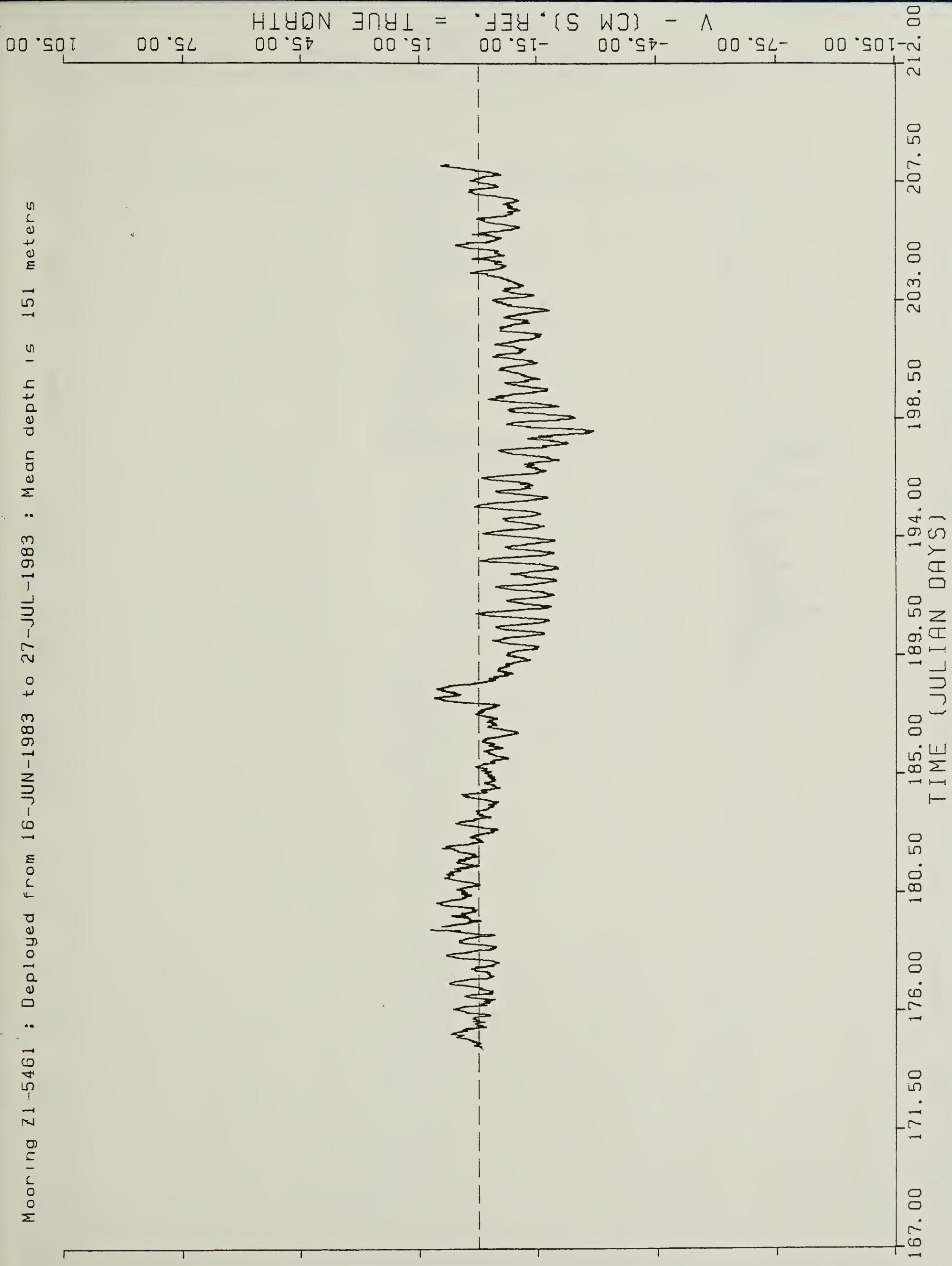


U - (CM S). REF. = TRUE NORTH

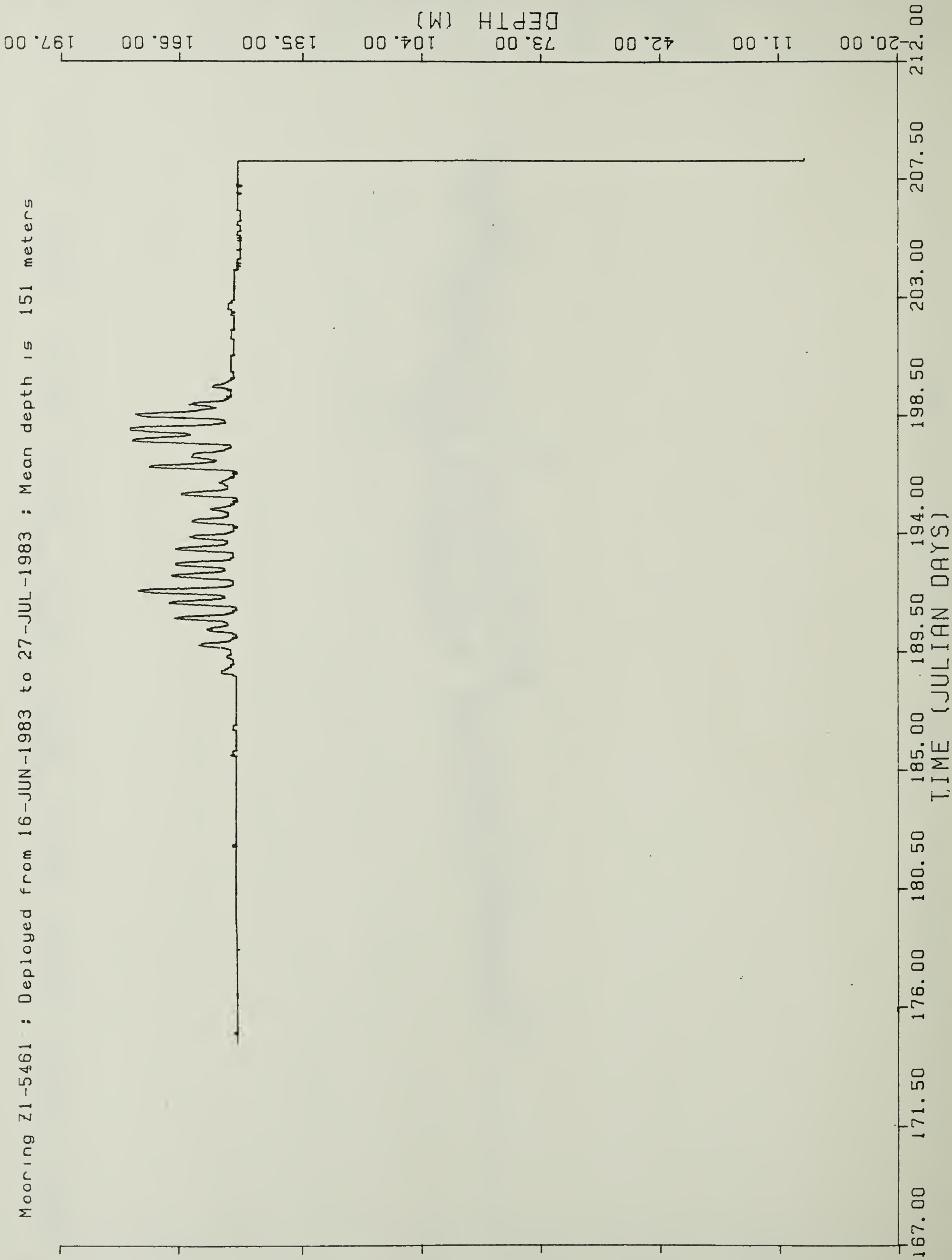
Mooring Z1-5461 : Deployed from 16-JUN-1983 to 27-JUL-1983 : Mean depth is 151 meters



Mooring Z1-5461 : Deployed from 16-JUN-1983 to 27-JUL-1983 : Mean depth is 151 meters



Mooring Z1-5461 : Deployed from 16-JUN-1983 to 27-JUL-1983 : Mean depth is 151 meters



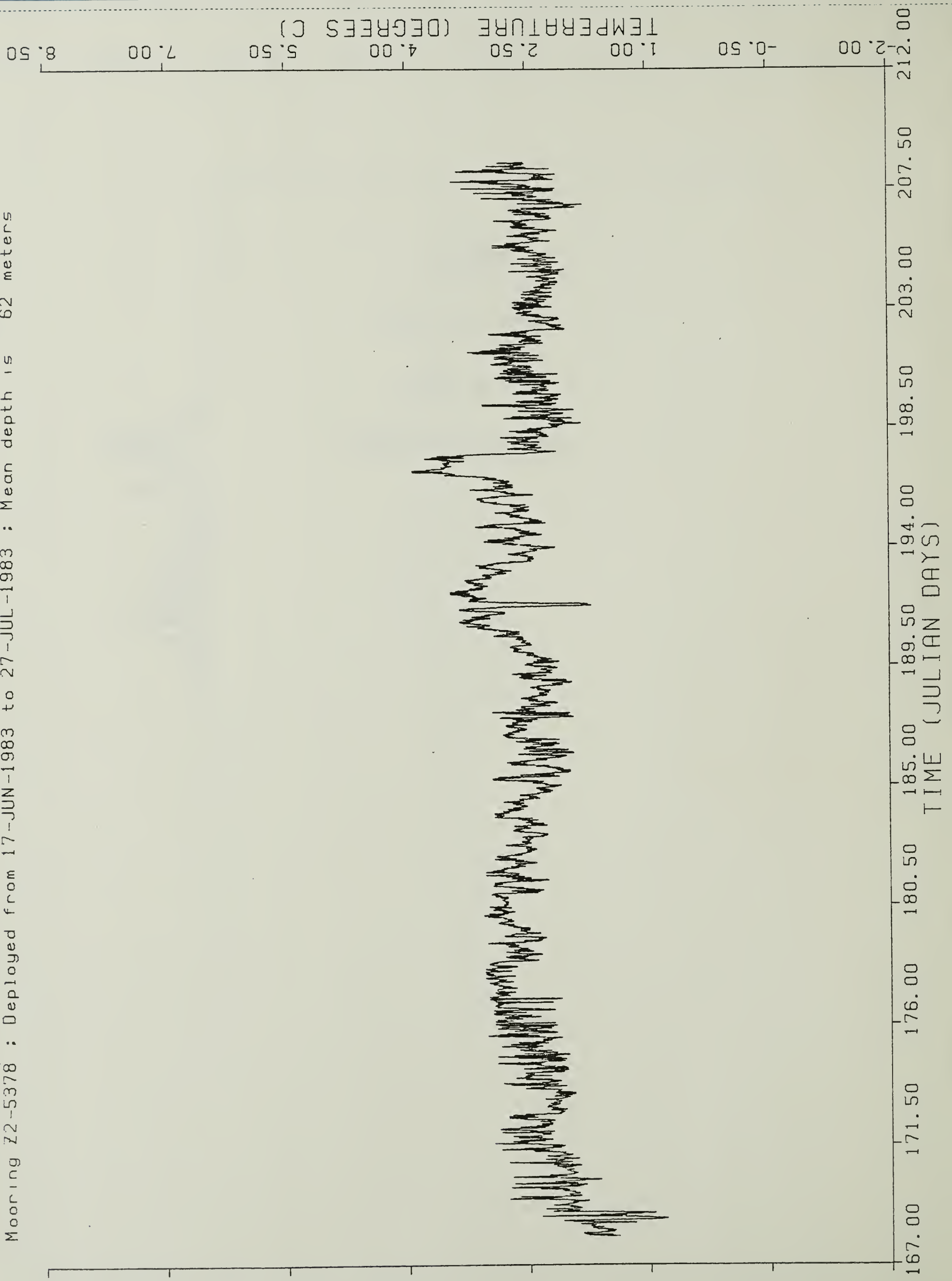
MOORING 2

RCM-5 No. 5378

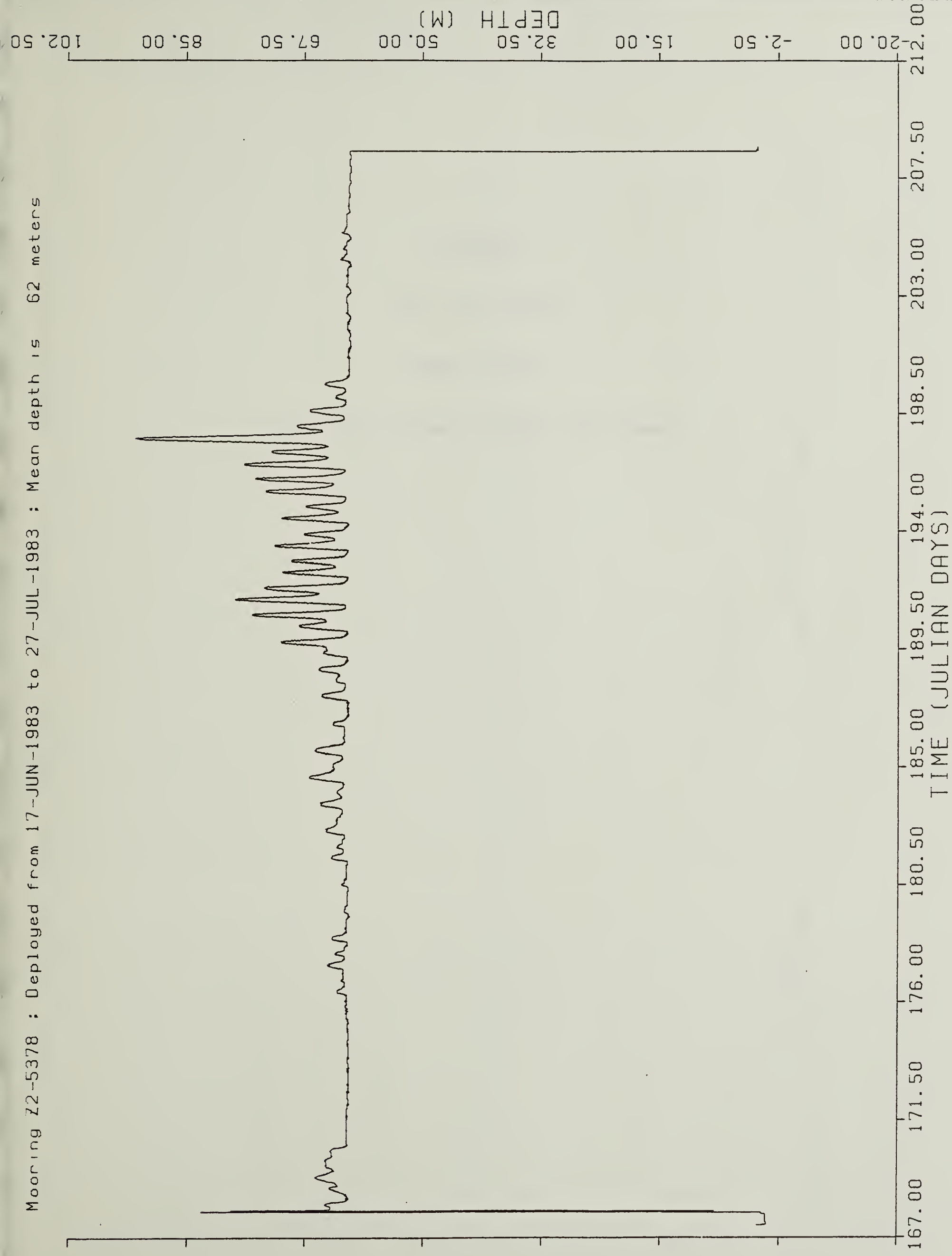
61 m Depth

Temperature and Depth

Mooring Z2-5378 : Deployed from 17-JUN-1983 to 27-JUL-1983 : Mean depth is 62 meters



Mooring Z2-5378 : Deployed from 17-JUN-1983 to 27-JUL-1983 : Mean depth is 62 meters



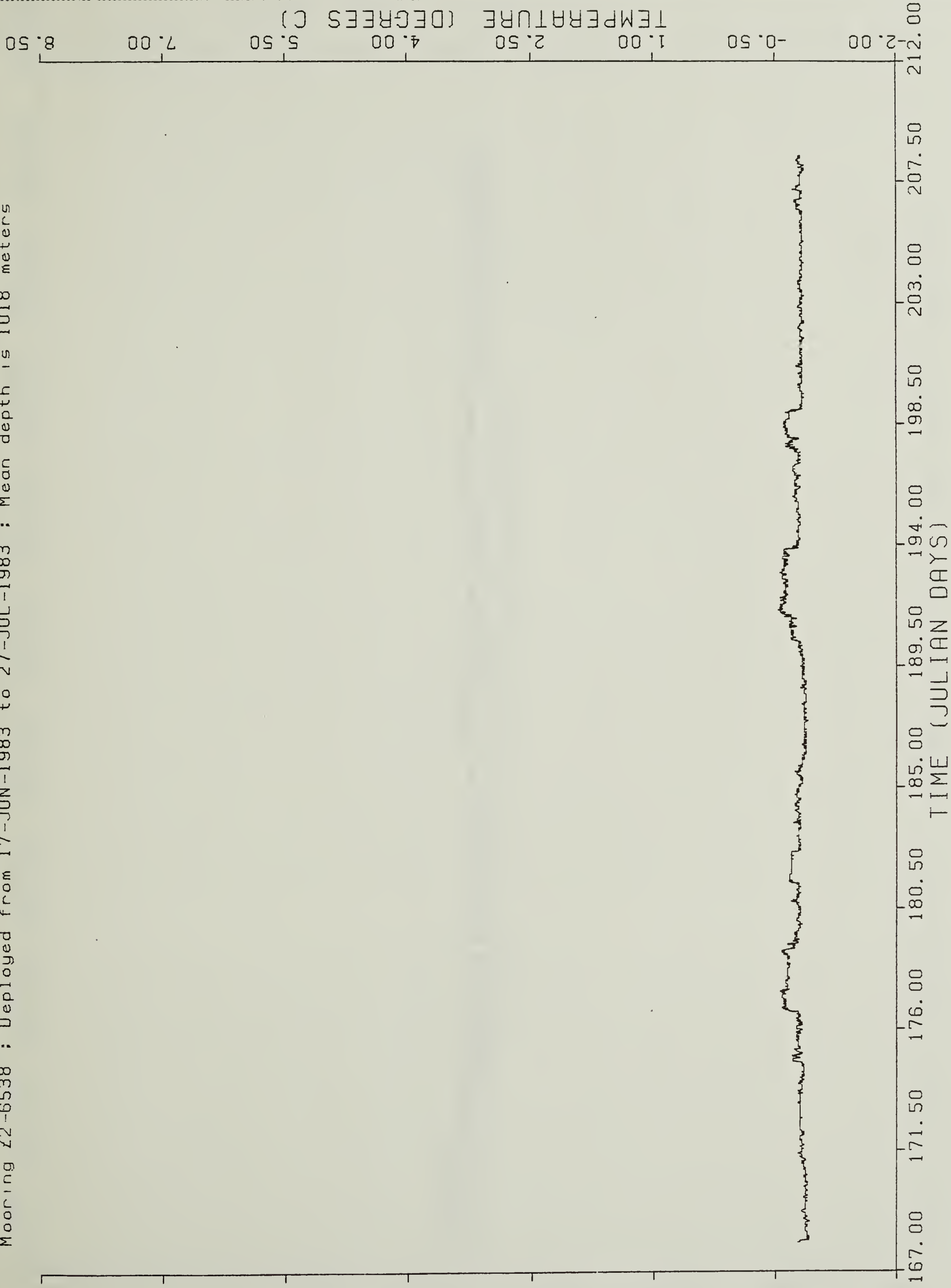
MOORING 2

RCM-5 No. 6538

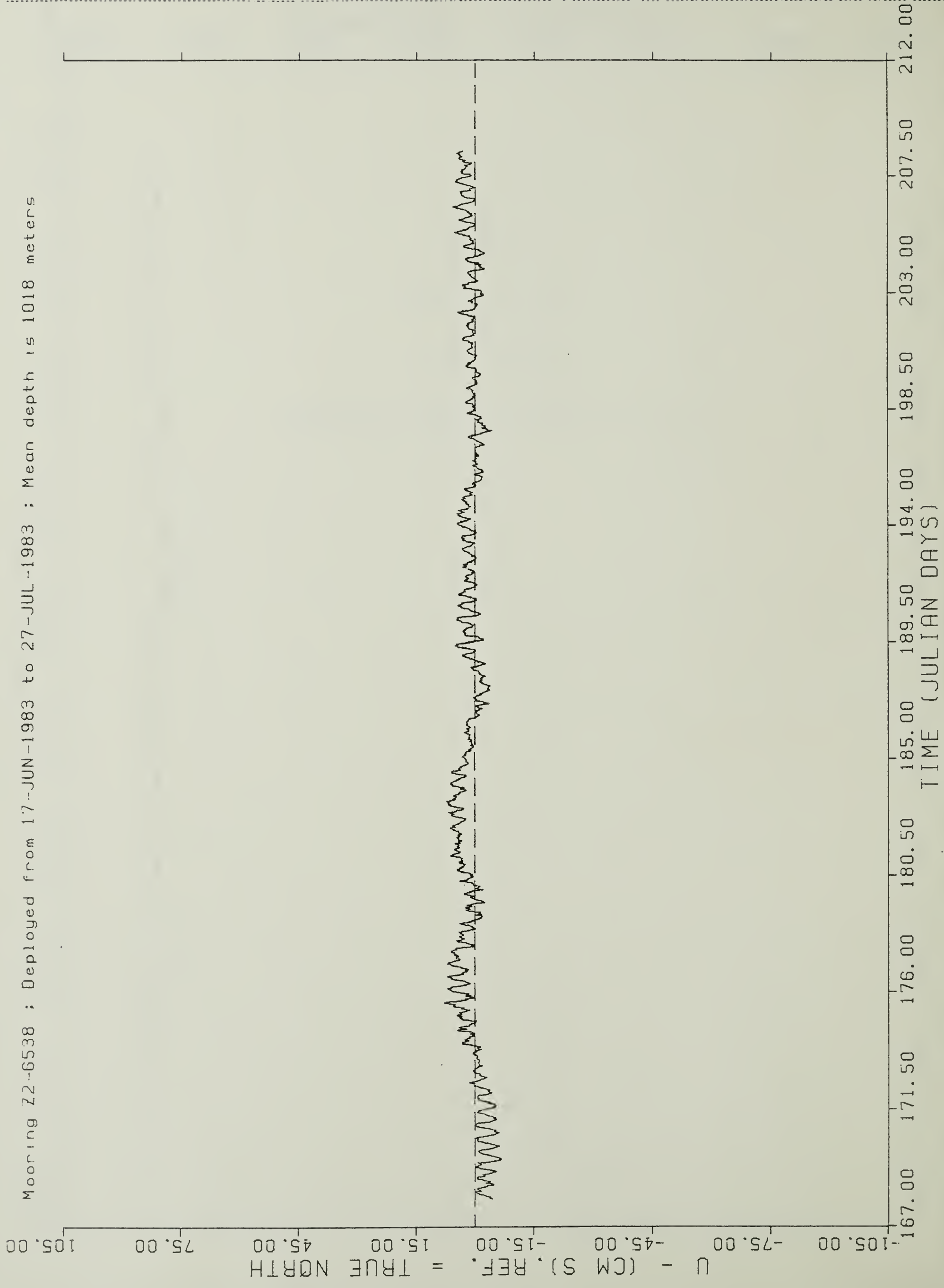
1,015 m Depth

Temperature, Current Components and Depth

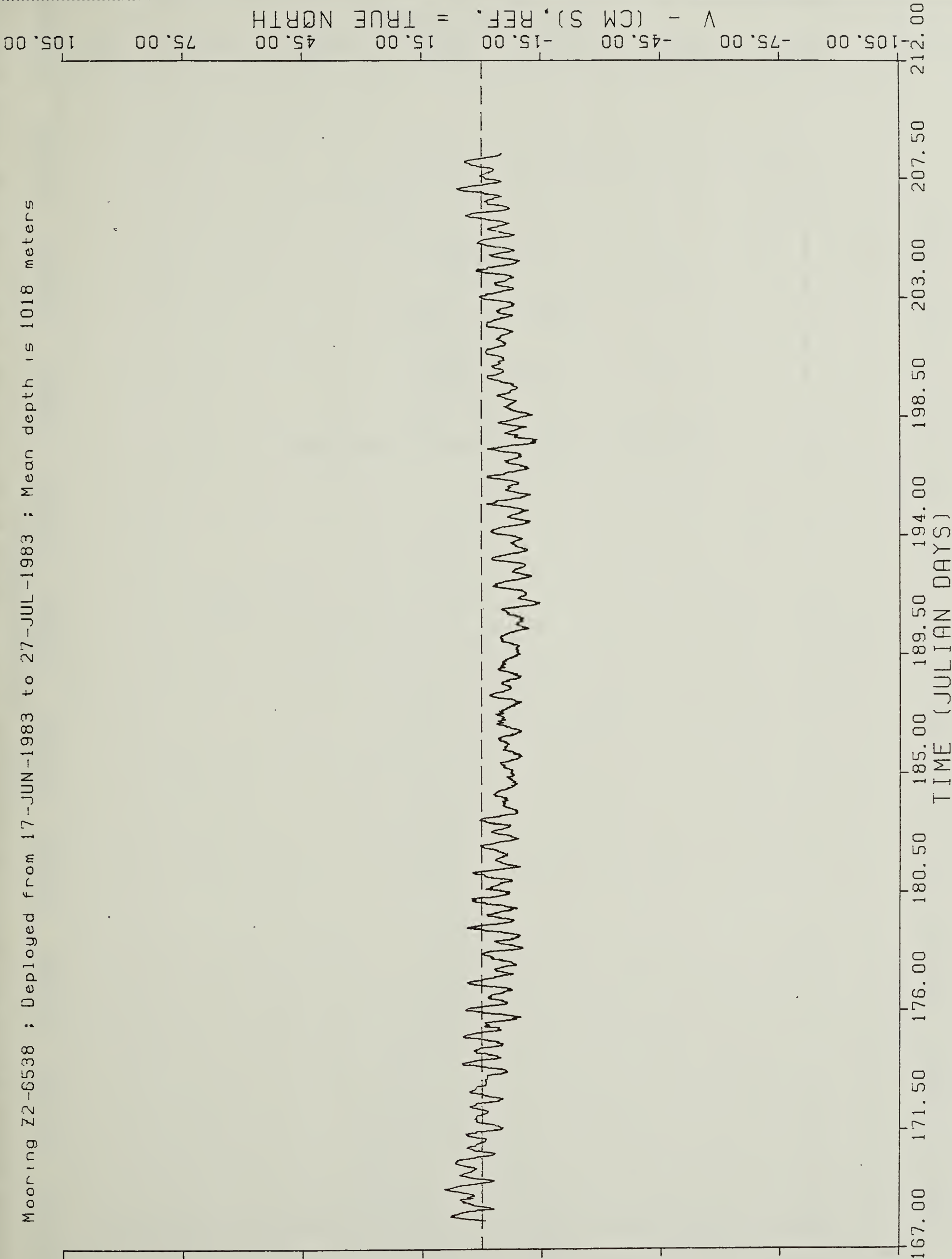
Mooring Z2-6538 : Deployed from 17-JUN-1983 to 27-JUL-1983 : Mean depth is 1018 meters



Mooring Z2-6538 ; Deployed from 17-JUN-1983 to 27-JUL-1983 ; Mean depth is 1018 meters



Mooring Z2-6538 : Deployed from 17-JUN-1983 to 27-JUL-1983 : Mean depth is 1018 meters



Mooring Z2-6538 : Deployed from 17-JUN-1983 to 27-JUL-1983 ; Mean depth is 1018 meters



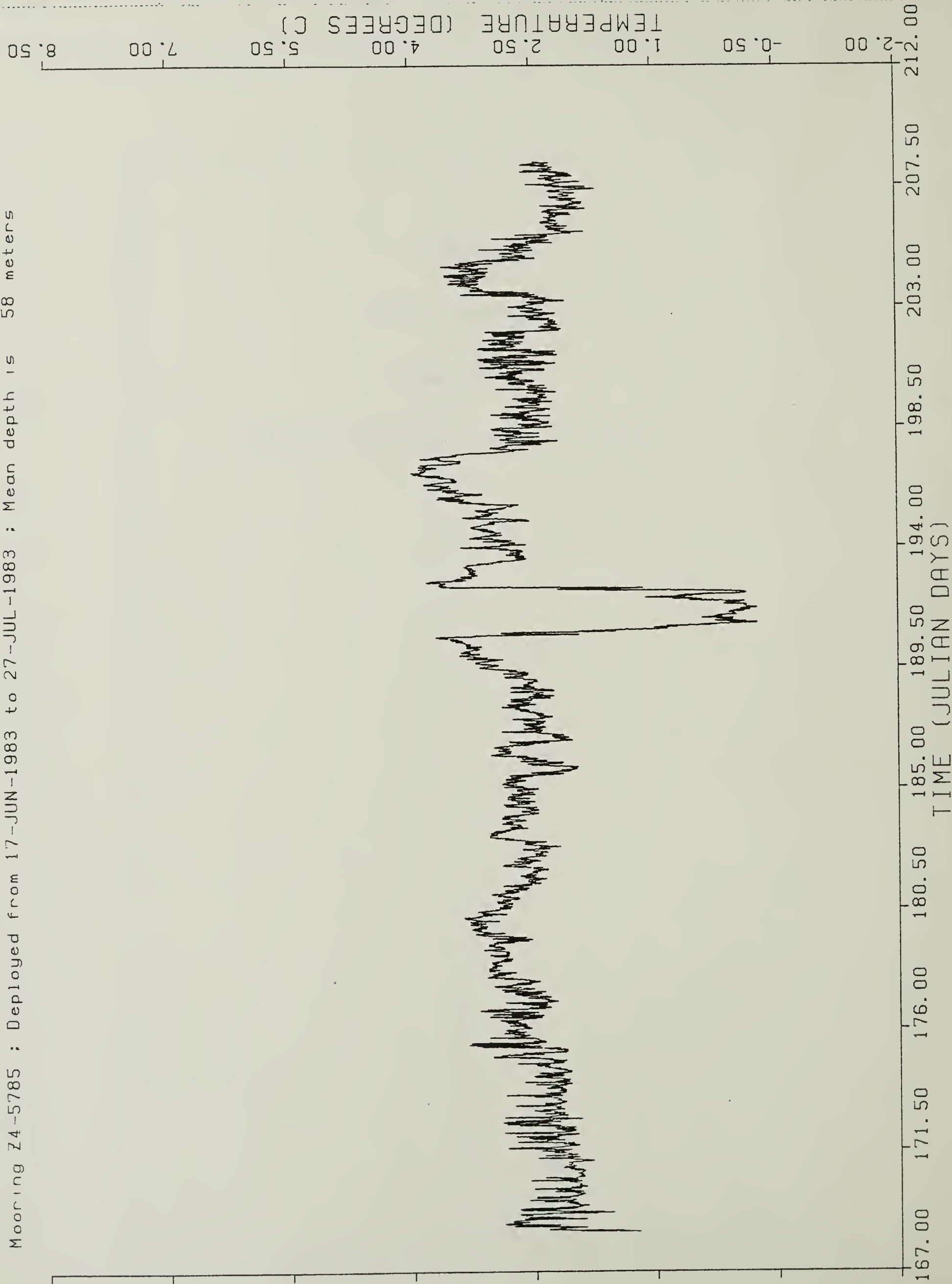
MOORING 4

RCM-5 No. 5785

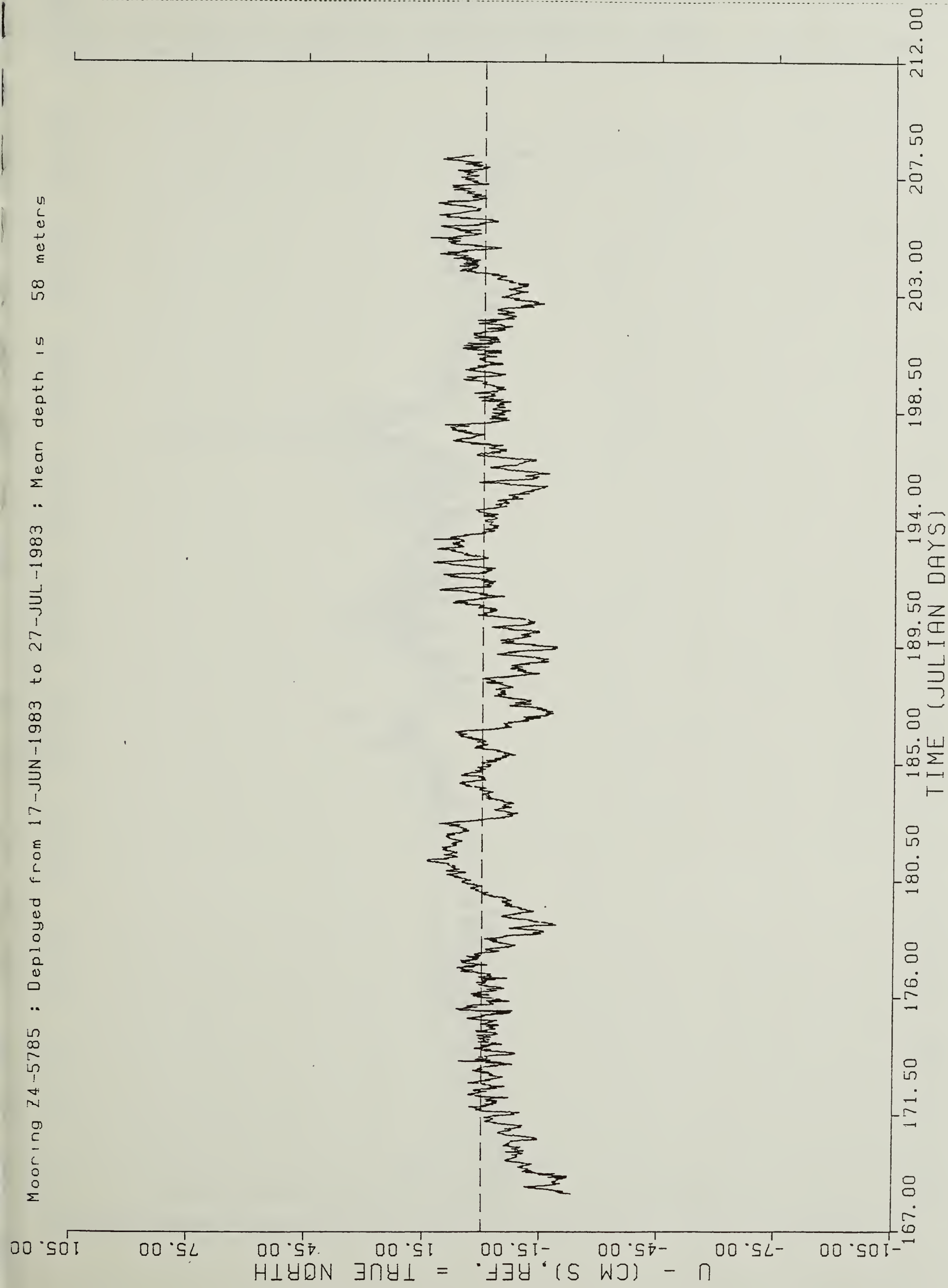
55 m Depth

Temperature, Current Components and Depth

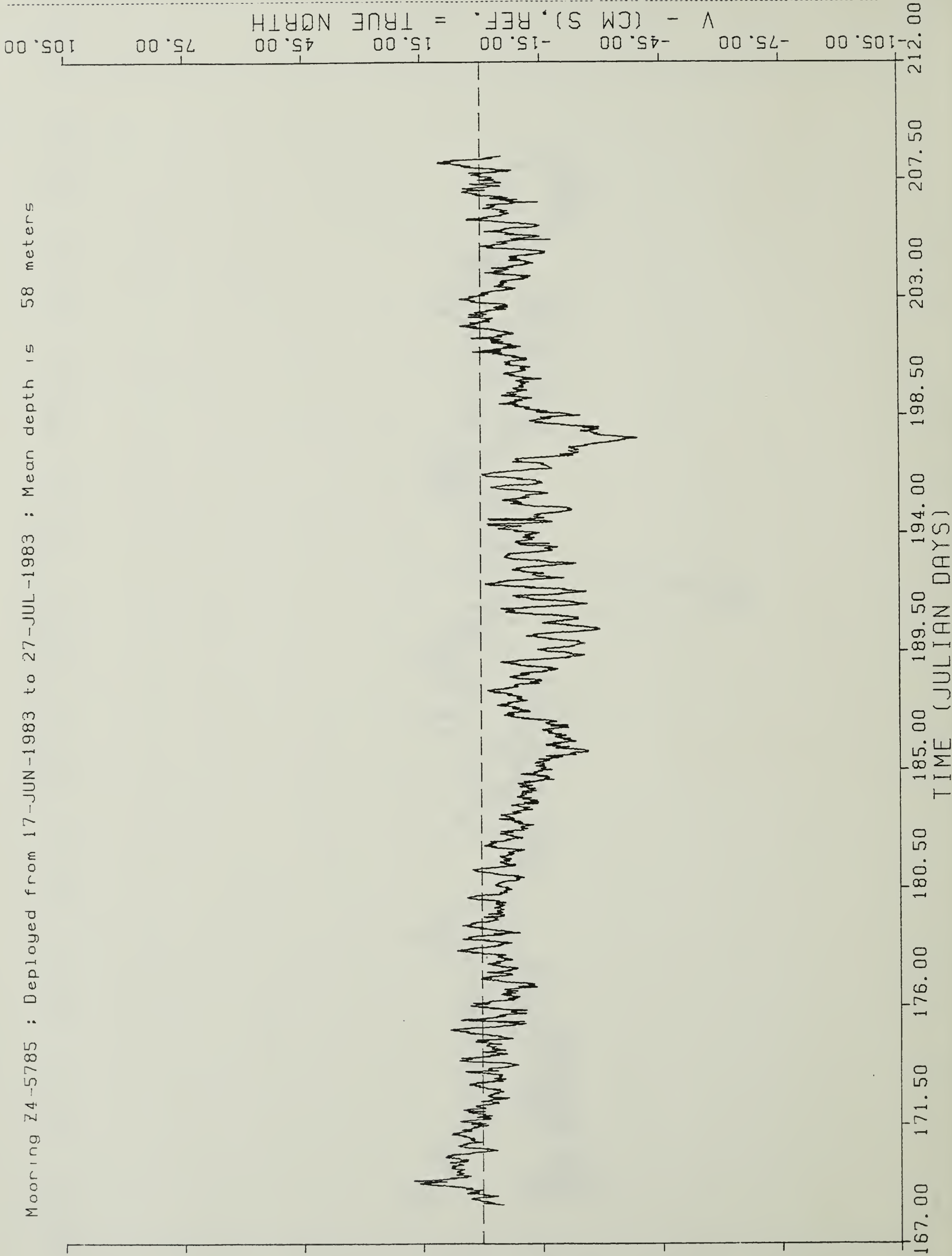
Mooring Z4-5785 ; Deployed from 17-JUN-1983 to 27-JUL-1983 ; Mean depth is 58 meters



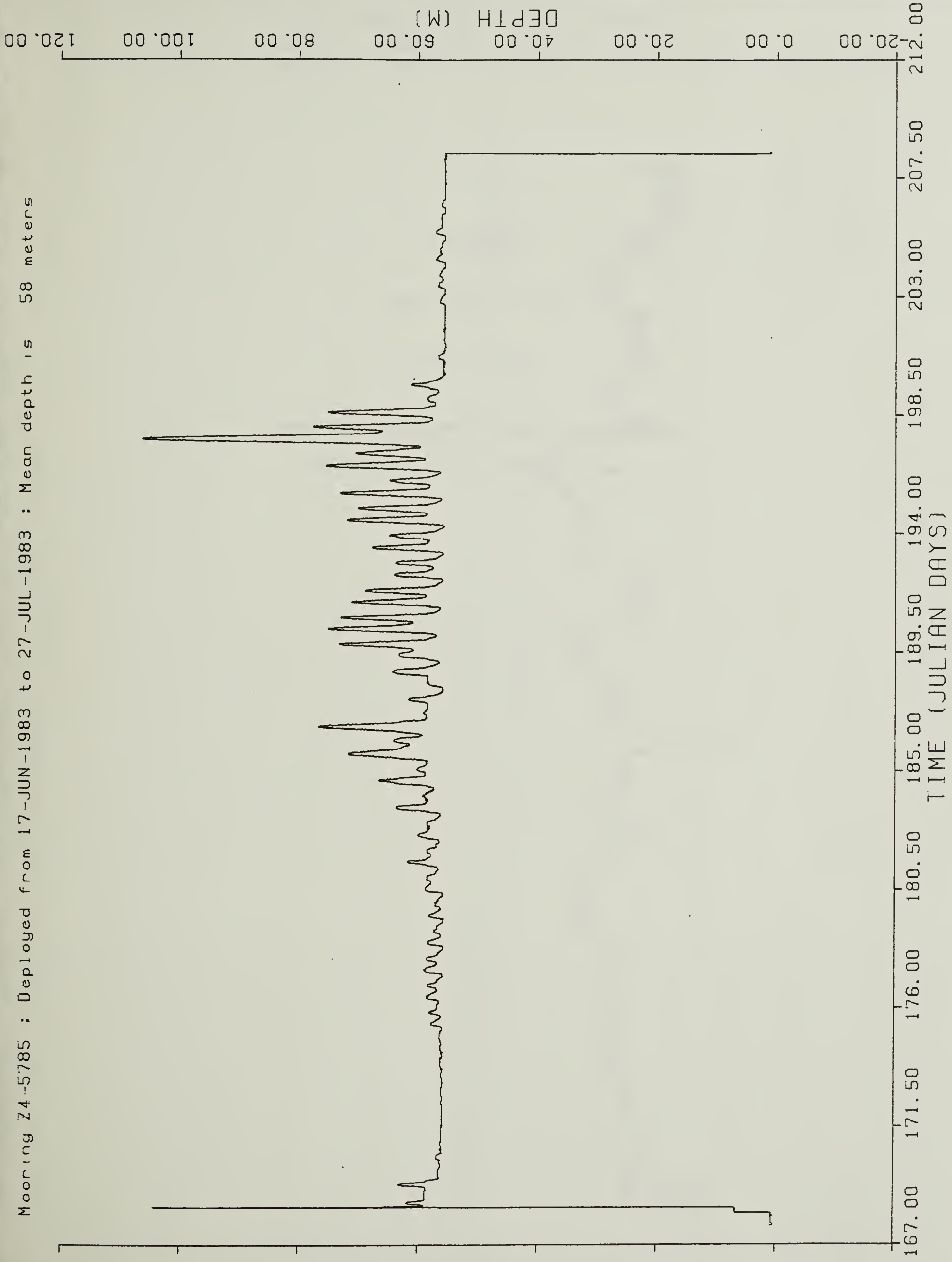
Mooring Z4-5785 : Deployed from 17-JUN-1983 to 27-JUL-1983 ; Mean depth is 58 meters



Mooring Z4-5785 : Deployed from 17-JUN-1983 to 27-JUL-1983 : Mean depth is 58 meters



Mooring Z4-5785 : Deployed from 17-JUN-1983 to 27-JUL-1983 : Mean depth is 58 meters



MOORING 4

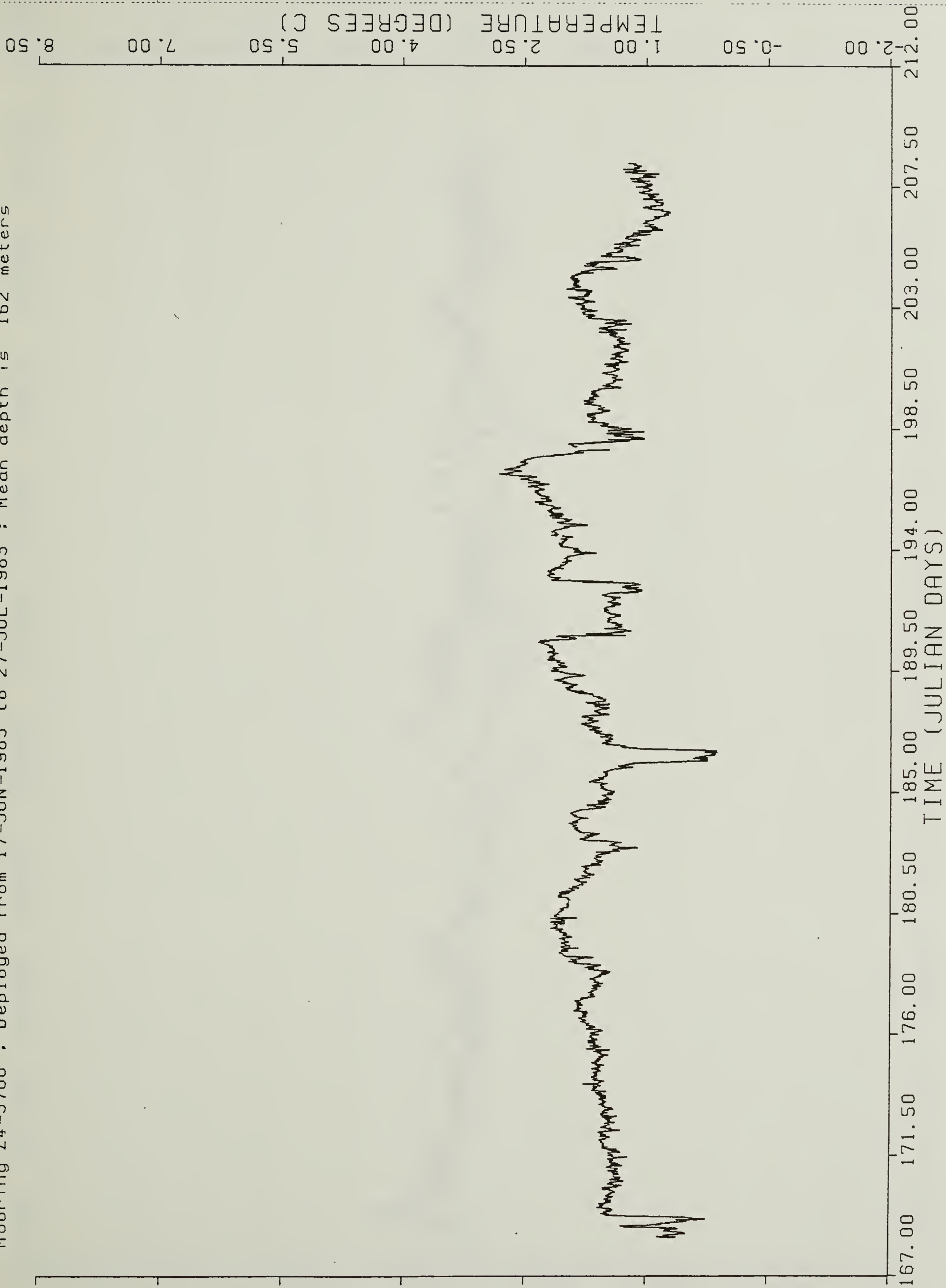
RCM-5 No. 5760

158 m Depth

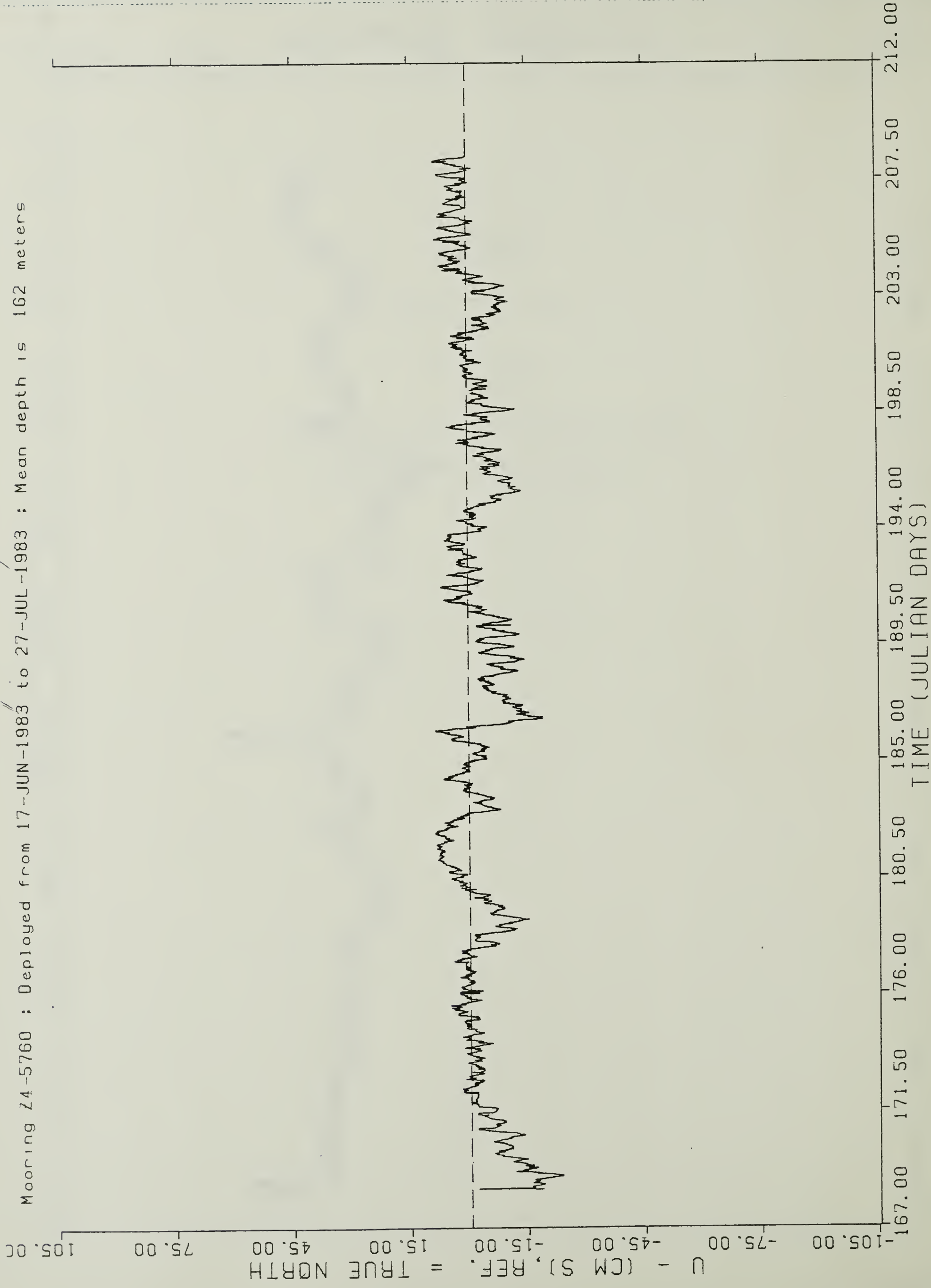
Temperature, Current Components and Depth

(Depth Record in Three Segments)

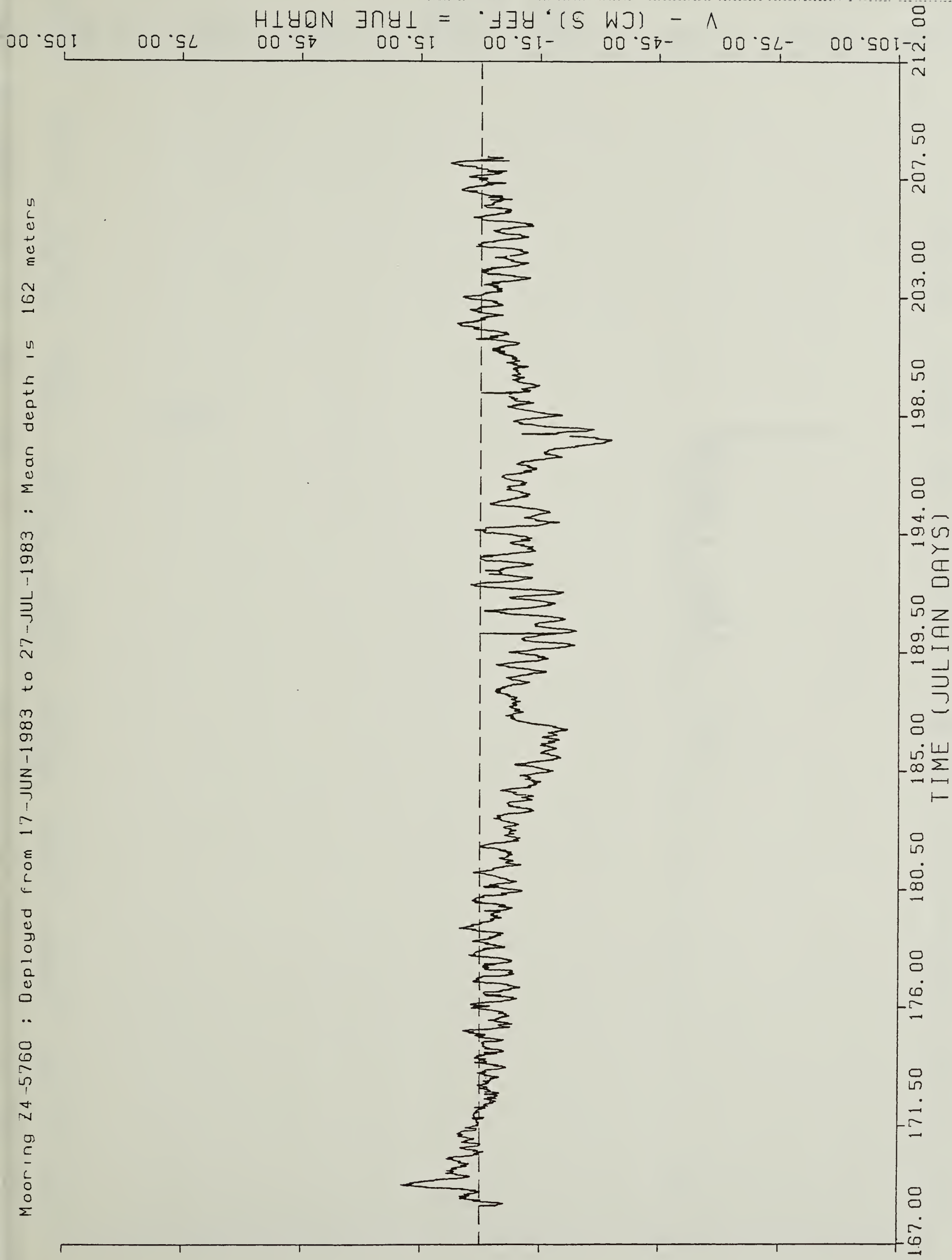
Mooring Z4-5760 : Deployed from 17-JUN-1983 to 27-JUL-1983 : Mean depth is 162 meters



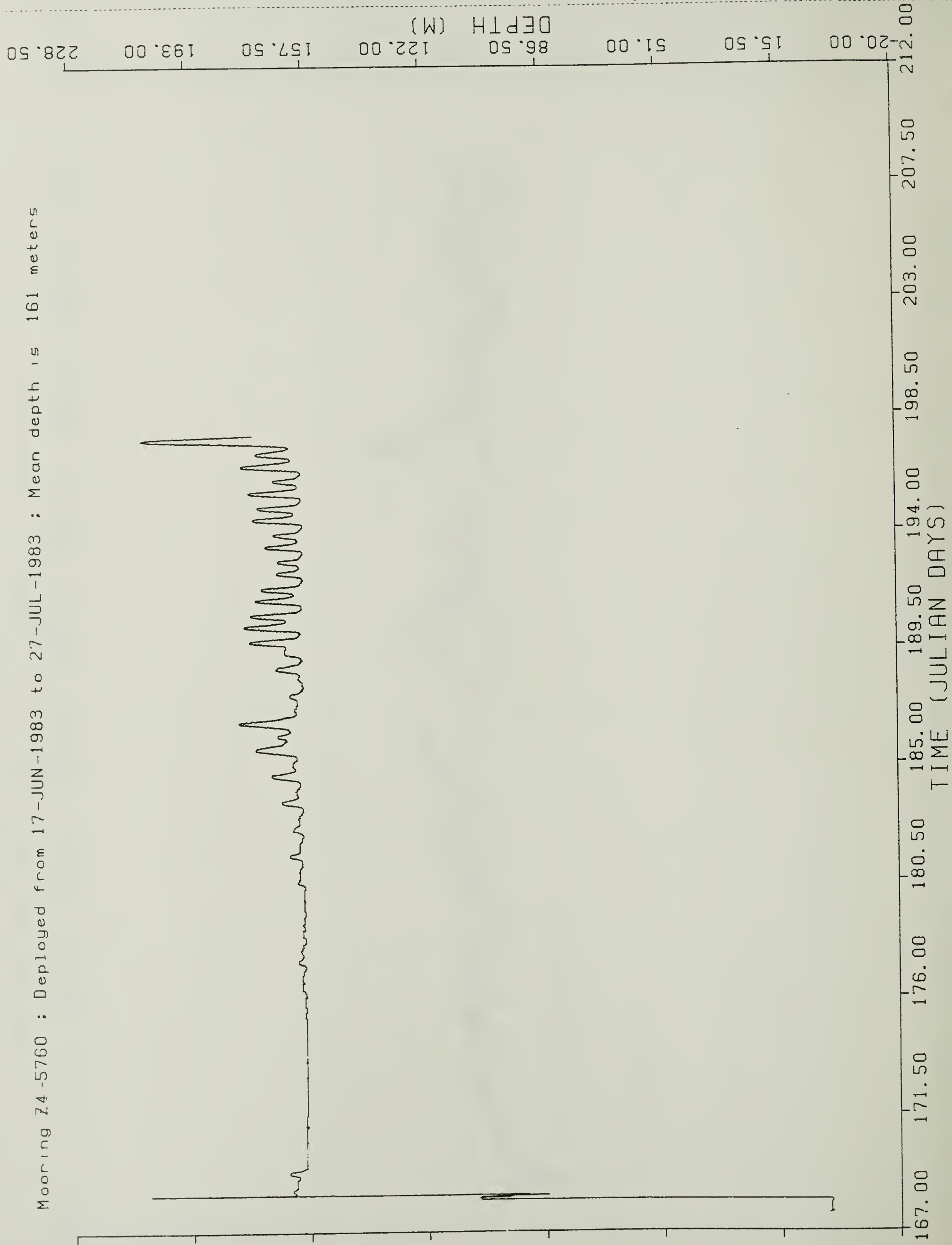
Mooring 24-5760 : Deployed from 17-JUN-1983 to 27-JUL-1983 : Mean depth is 162 meters



Mooring Z4-5760 : Deployed from 17-JUN-1983 to 27-JUL-1983 ; Mean depth is 162 meters

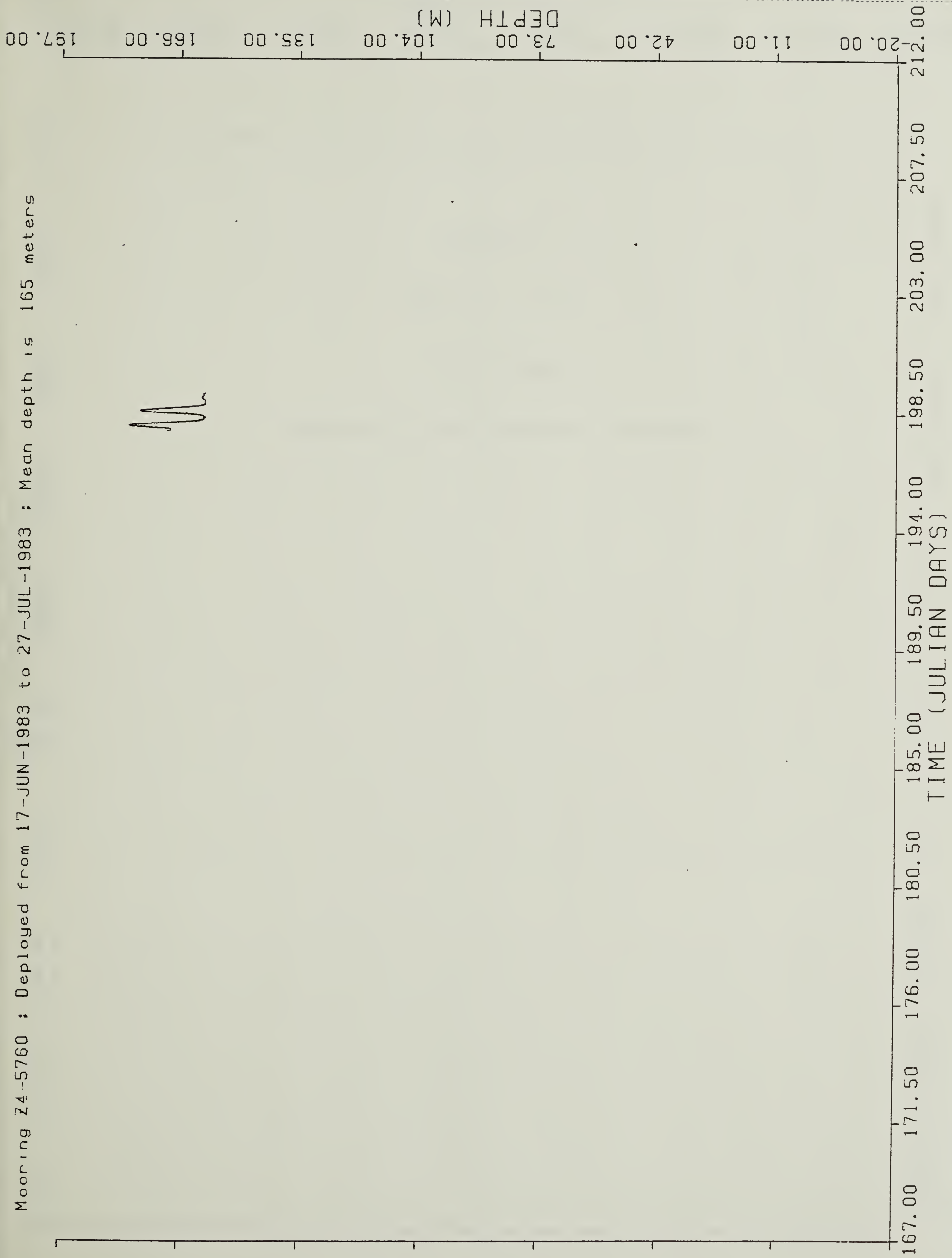


Mooring Z4-5760 : Deployed from 17-JUN-1983 to 27-JUL-1983 ; Mean depth is 161 meters

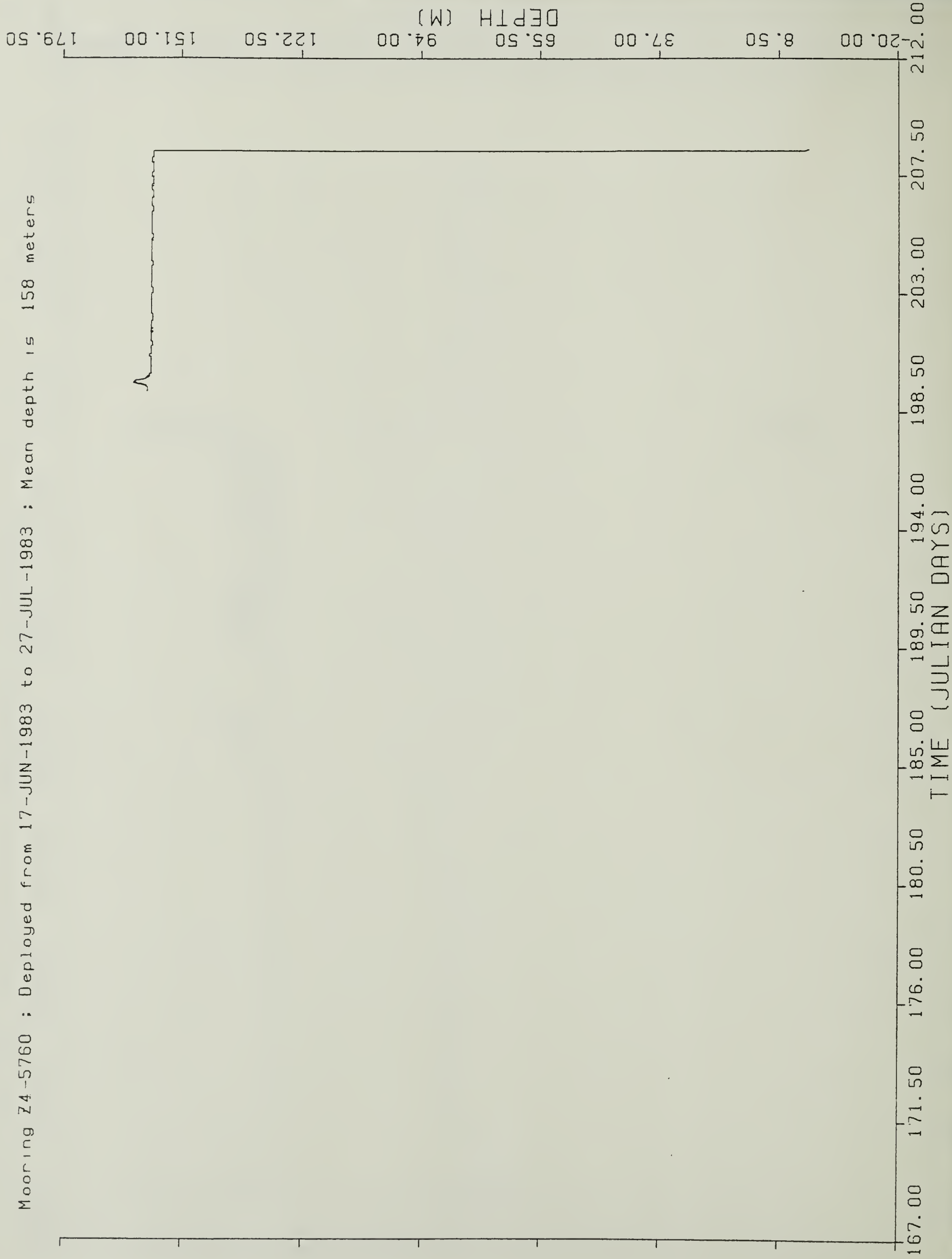


Mooring Z4-5760 : Deployed from 17-JUN-1983 to 27-JUL-1983 : Mean depth is 165 meters

W



Mooring Z4-5760 : Deployed from 17-JUN-1983 to 27-JUL-1983 ; Mean depth is 158 meters



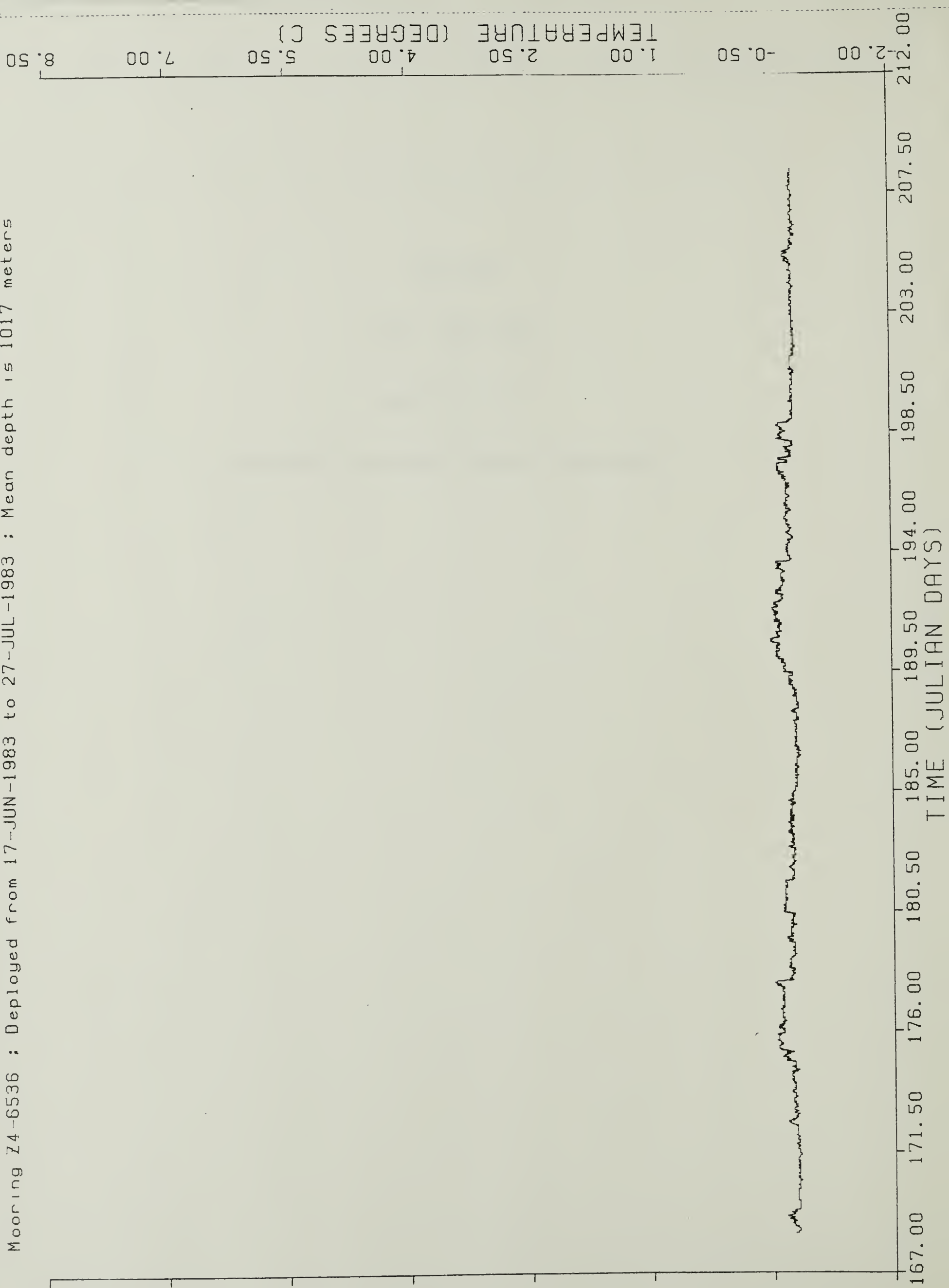
MOORING 4

RCM-5 No. 6536

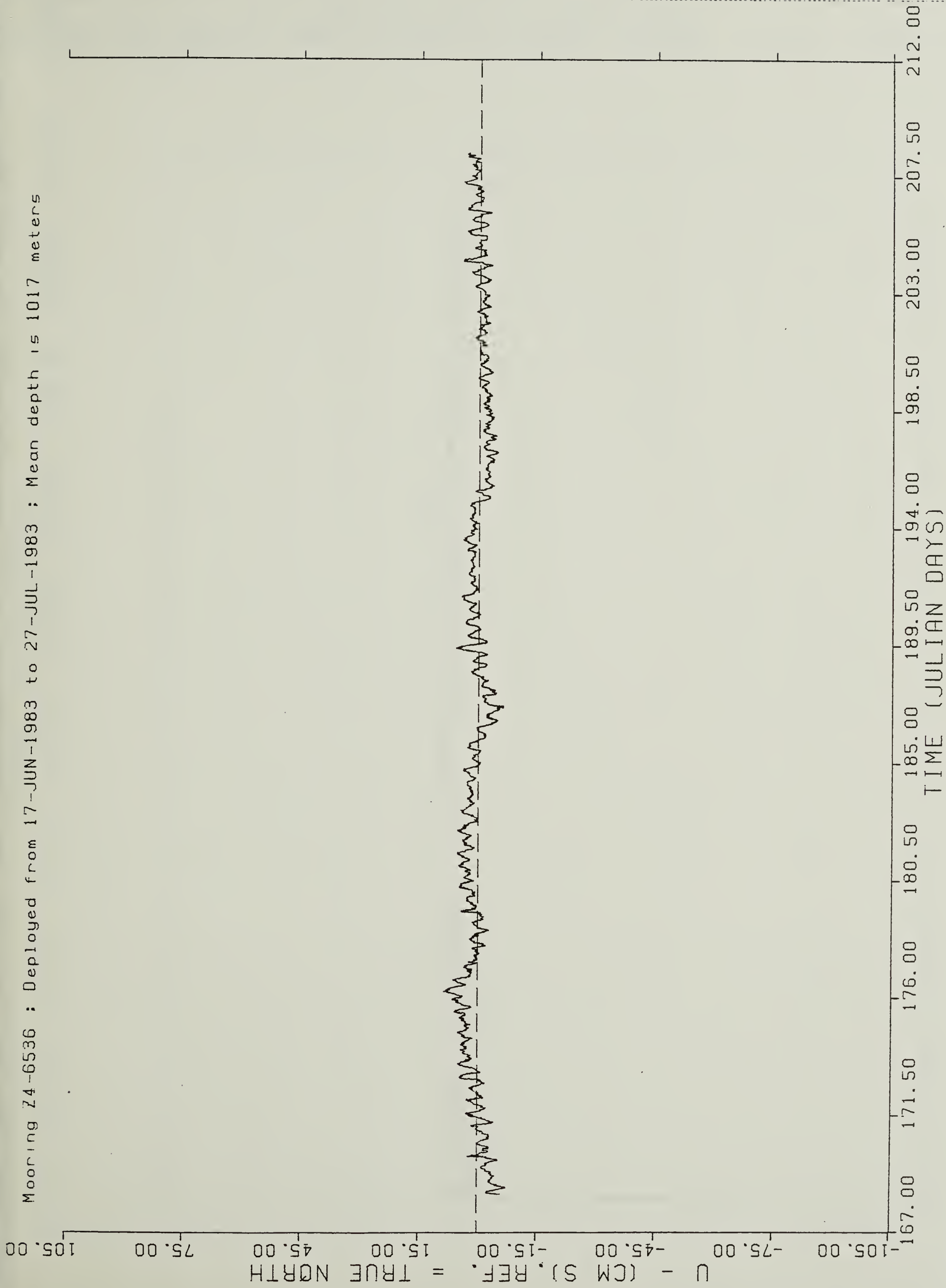
1,014 m Depth

Temperature, Current Components and Depth

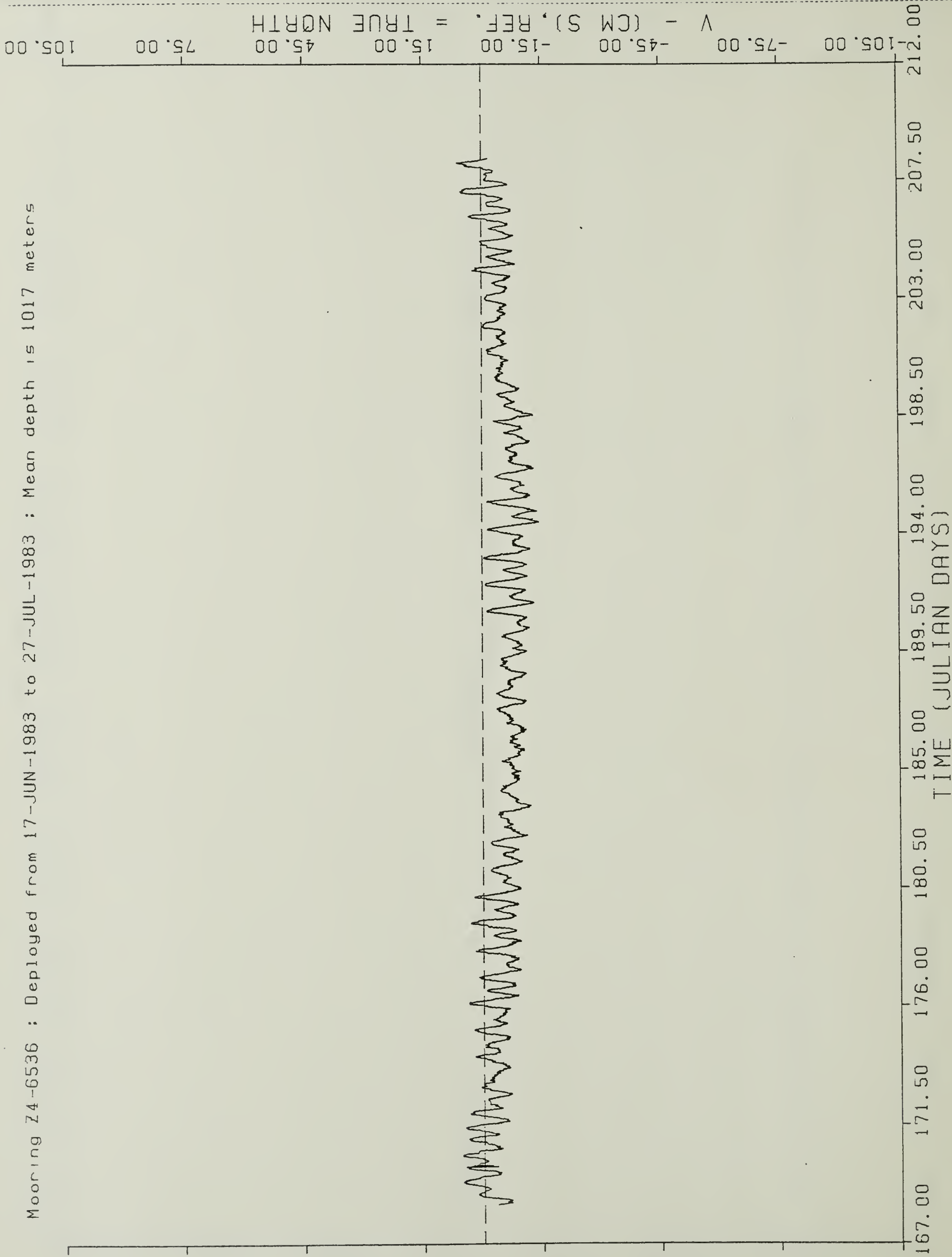
Mooring Z4-6536 ; Deployed from 17-JUN-1983 to 27-JUL-1983 ; Mean depth is 1017 meters



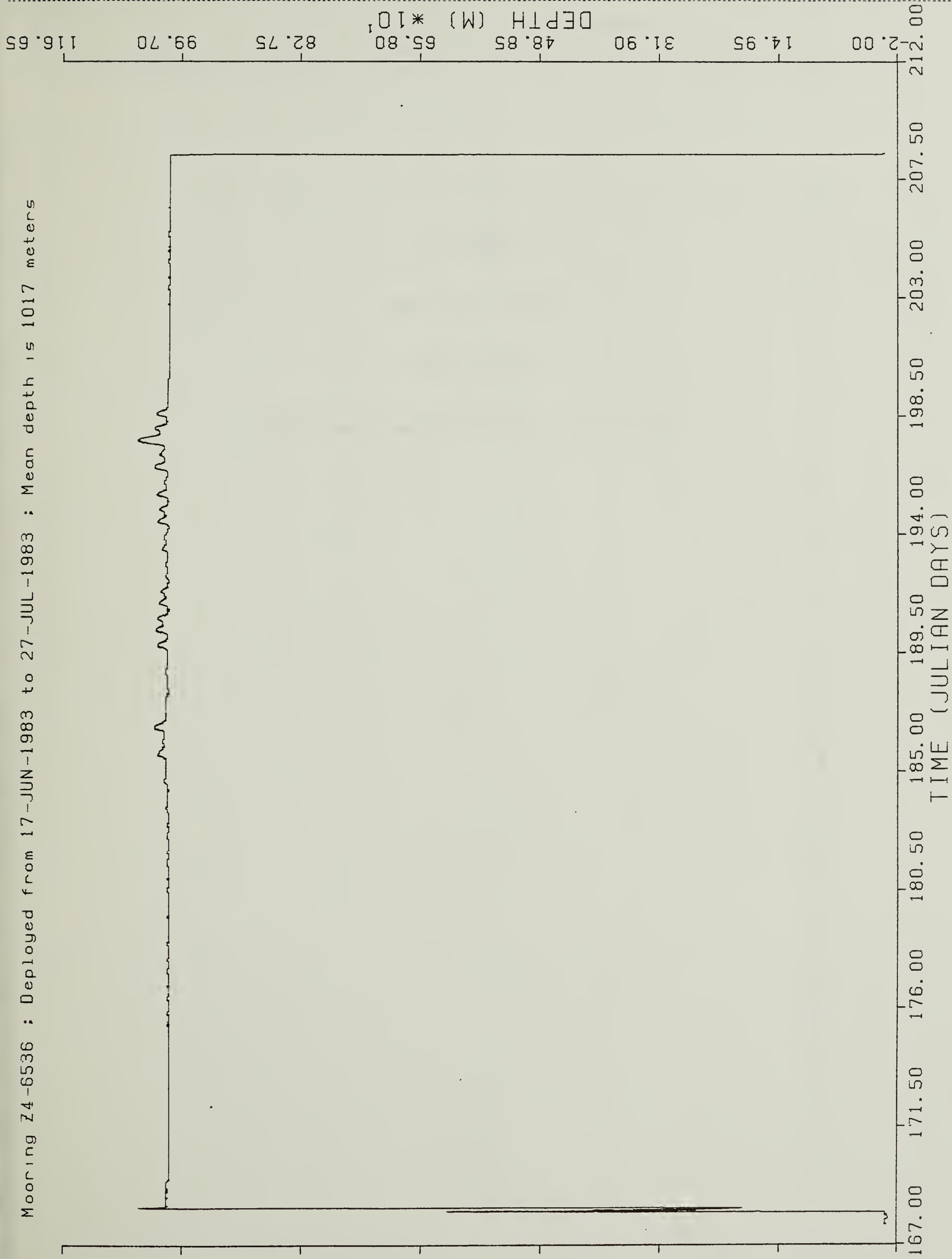
Mooring Z4-6536 : Deployed from 17-JUN-1983 to 27-JUL-1983 ; Mean depth is 1017 meters



Mooring Z4-6536 : Deployed from 17-JUN-1983 to 27-JUL-1983 : Mean depth is 1017 meters



Mooring Z4-6536 : Deployed from 17-JUN-1983 to 27-JUL-1983 : Mean depth is 1017 meters



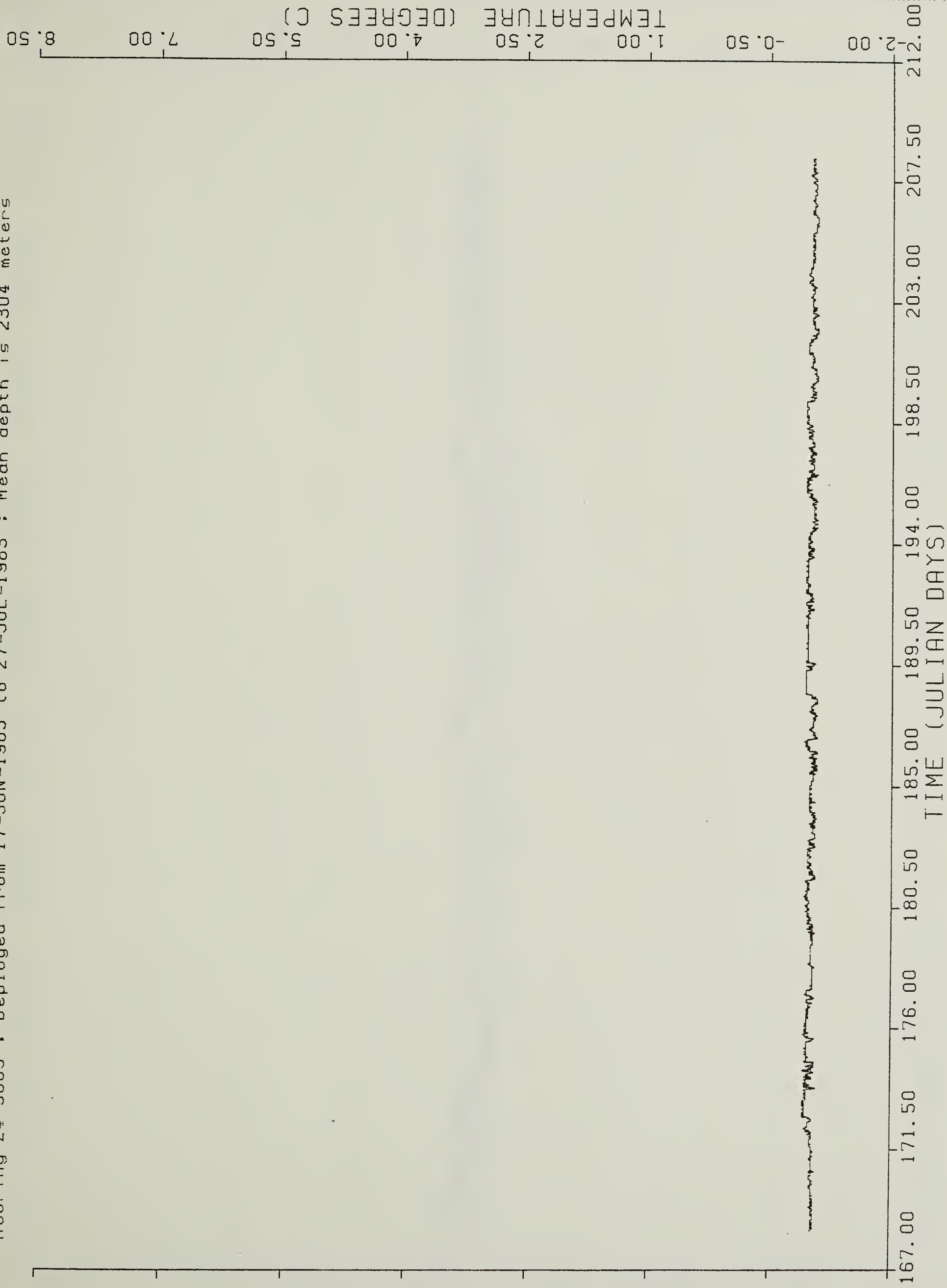
MOORING 4

RCM-5 No. 5889

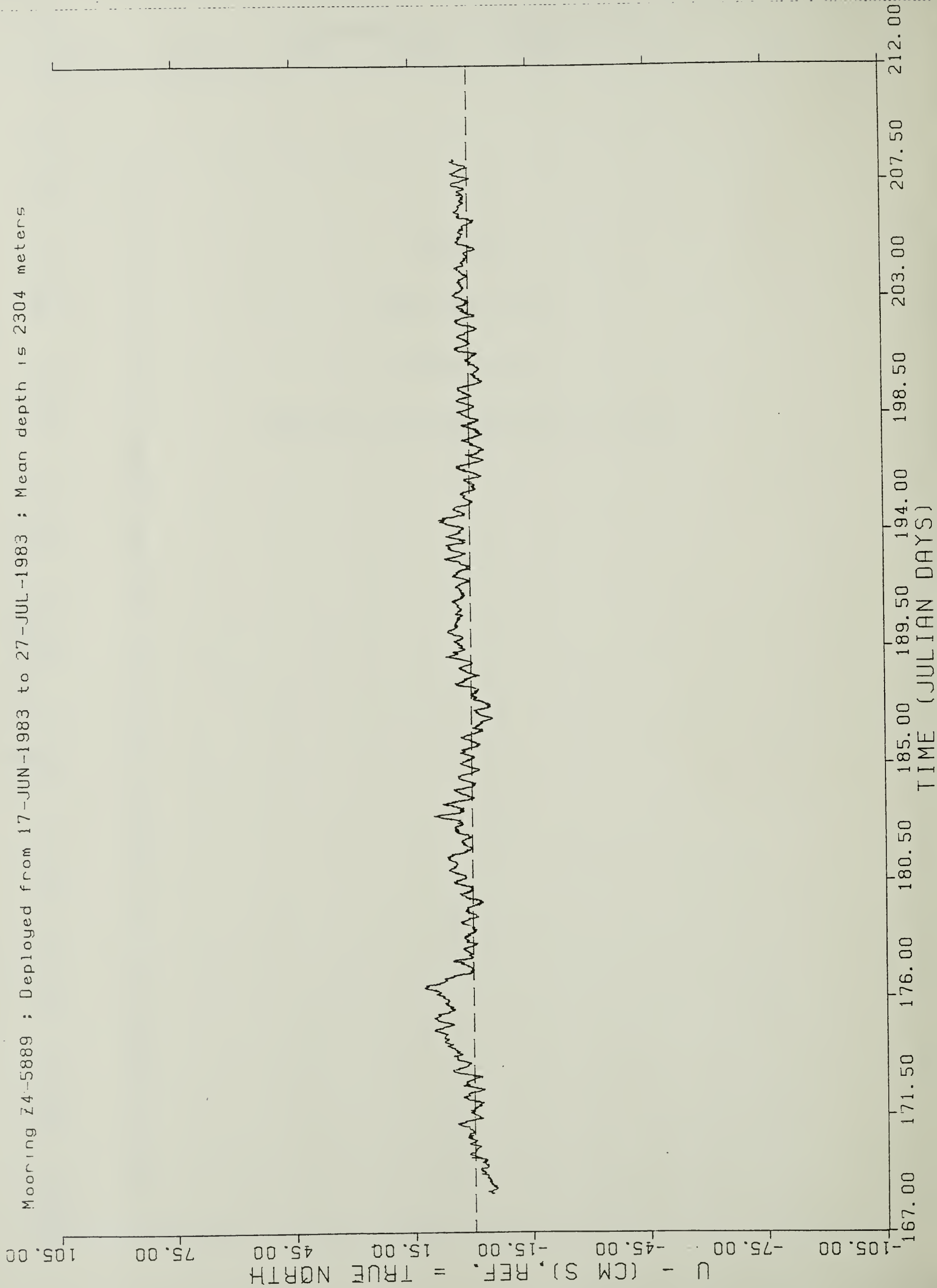
2,296 m Depth

Temperature, Current Components and Depth

Mooring Z4-5889 : Deployed from 17-JUN-1983 to 27-JUL-1983 : Mean depth is 2304 meters



Mooring Z4-5889 : Deployed from 17-JUN-1983 to 27-JUL-1983 ; Mean depth is 2304 meters



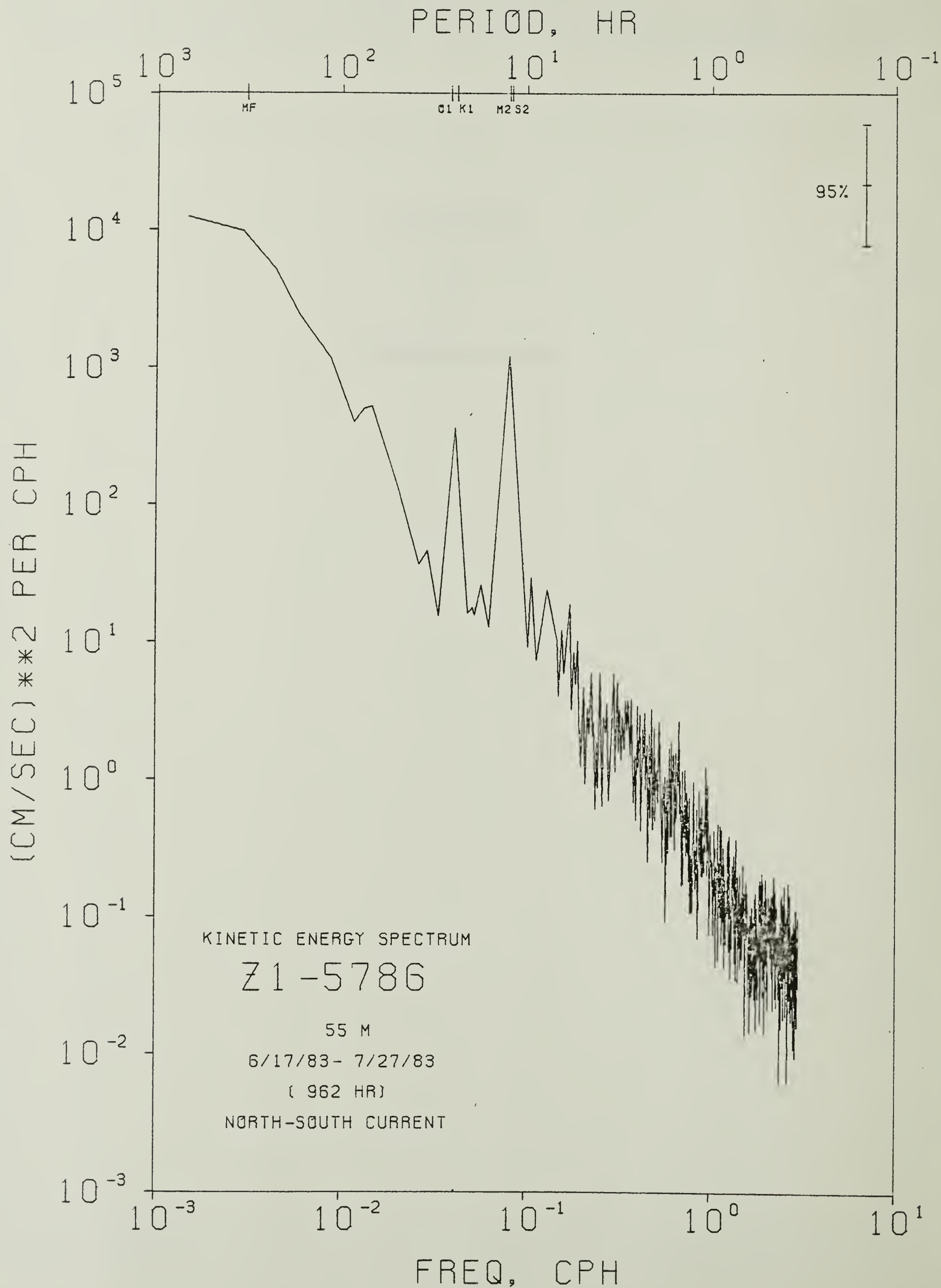
Mooring Z4-5889 : Deployed from 17-JUN-1983 to 27-JUL-1983 : Mean depth is 2304 meters

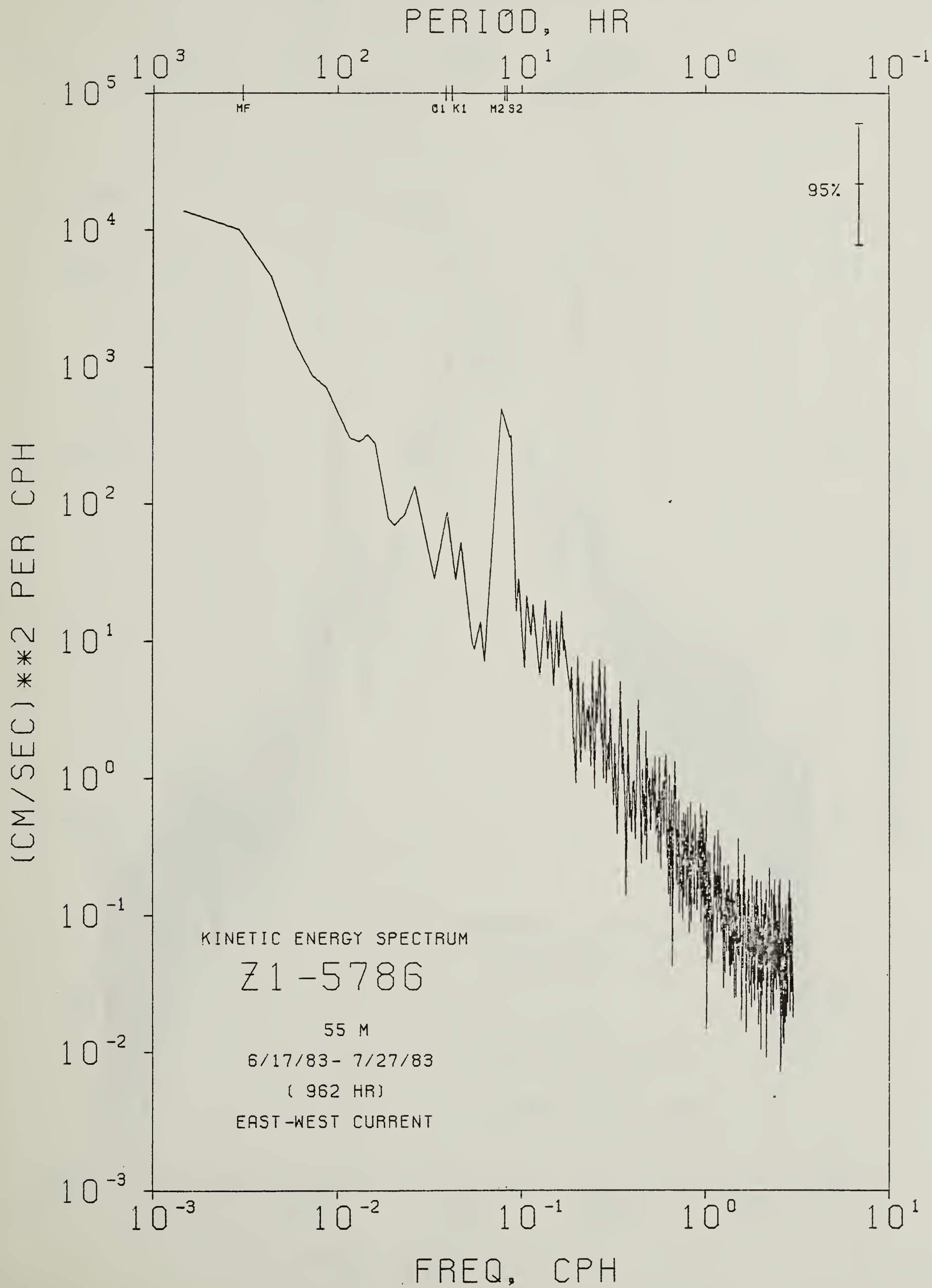


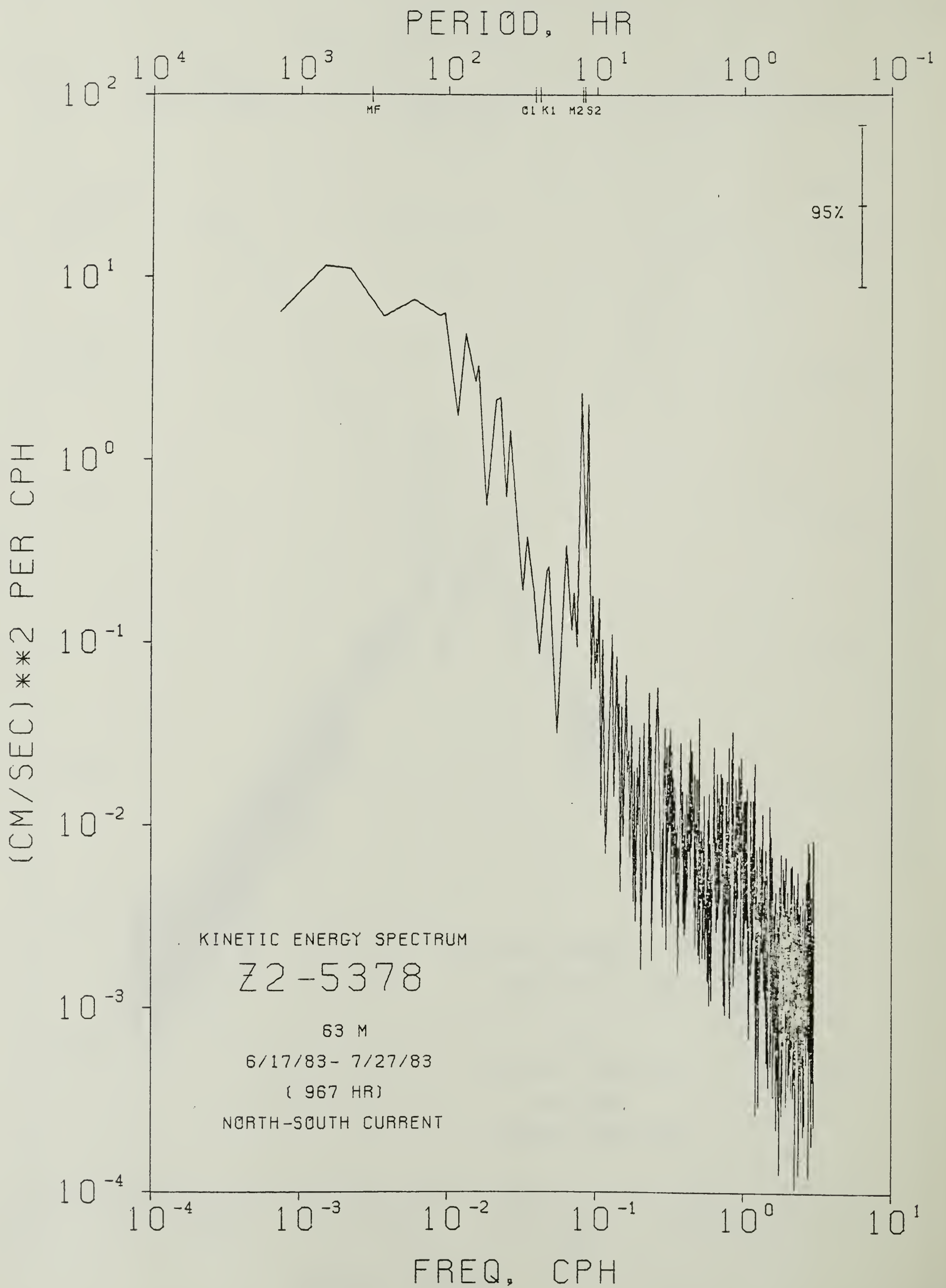
Mooring Z4-5889 : Deployed from 17-JUN-1983 to 27-JUL-1983 : Mean depth is 2304 meters

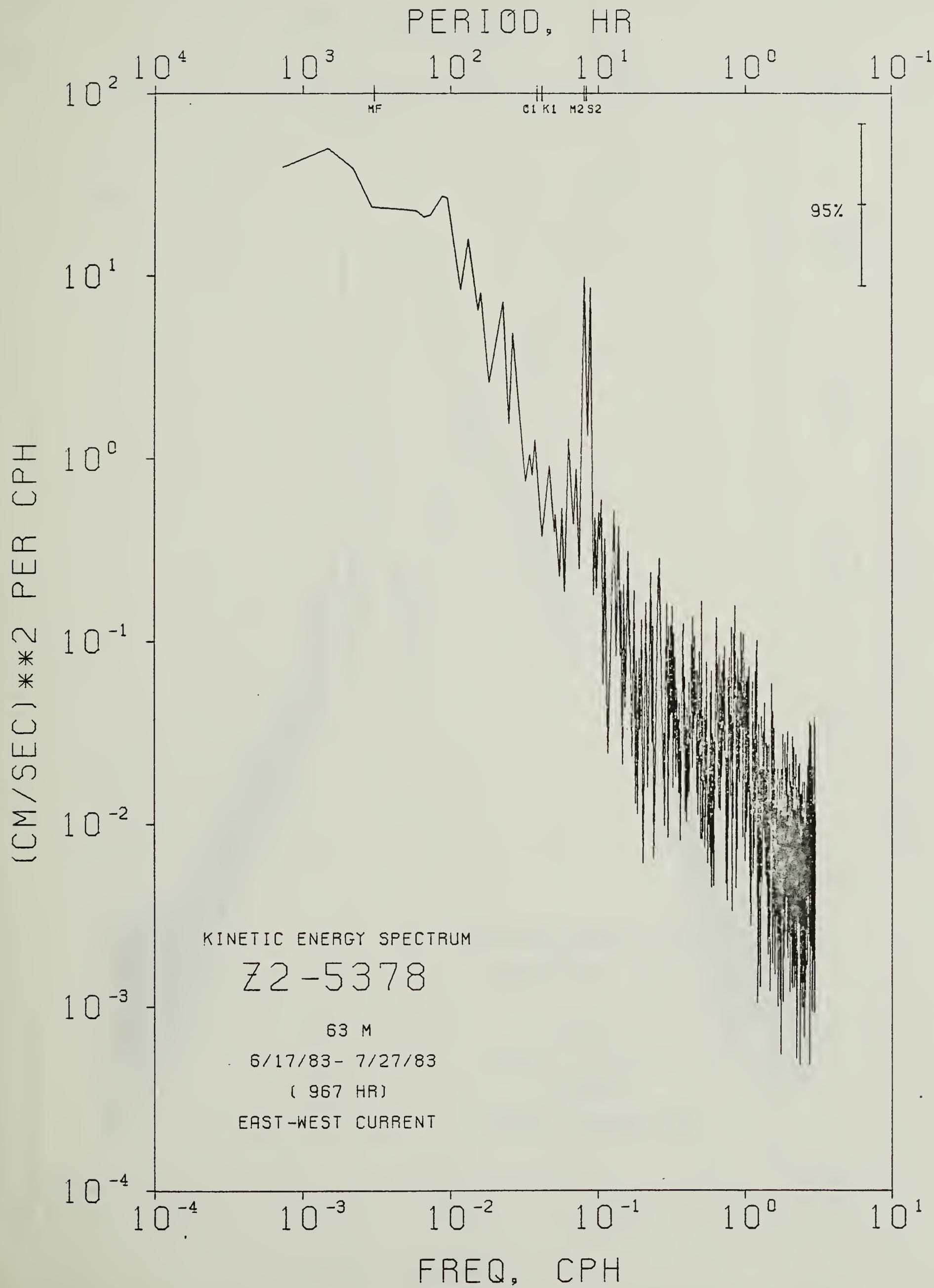


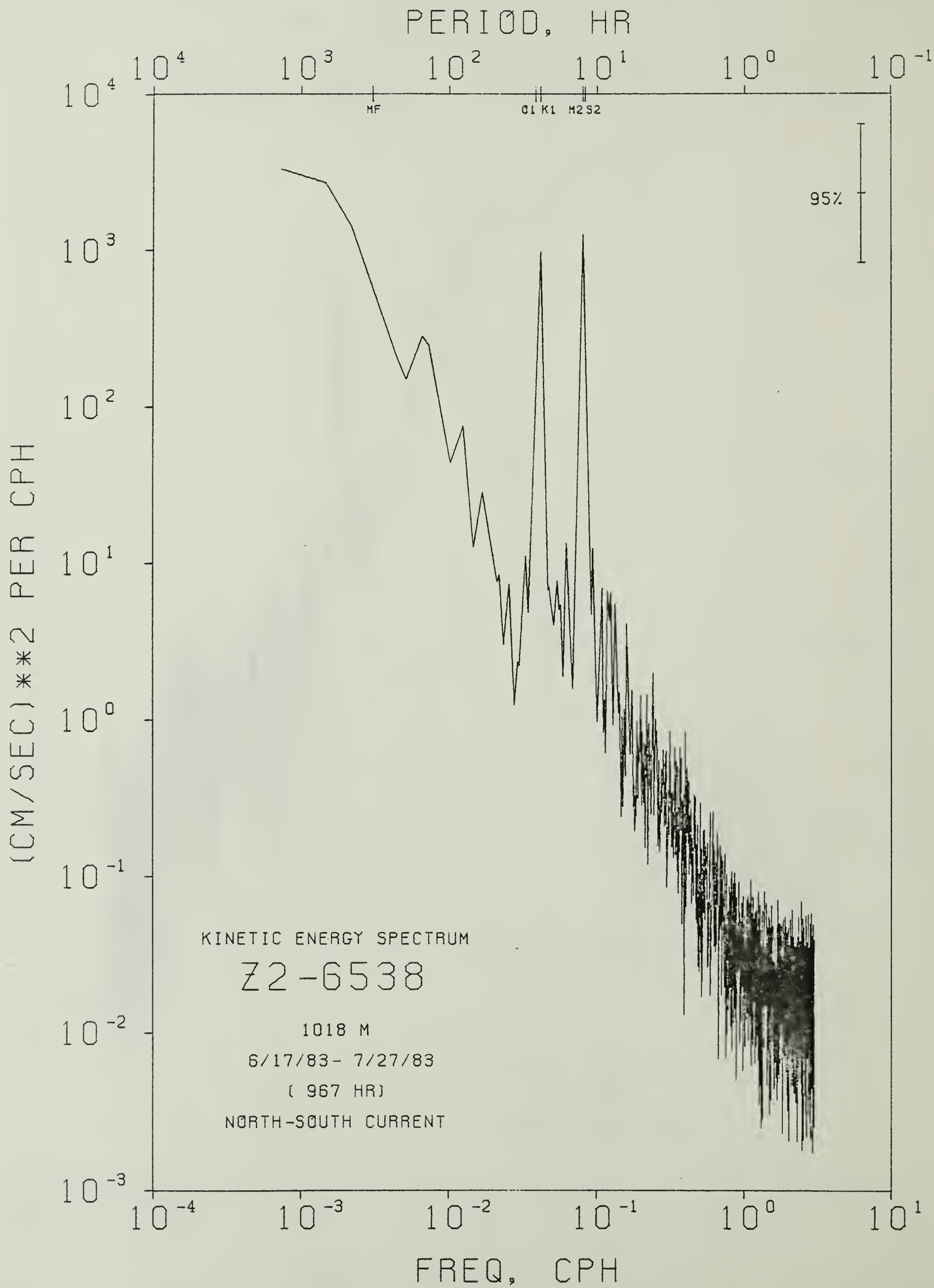
POWER SPECTRA
of
CURRENT COMPONENTS











PERIOD, HR

10^3 10^4 10^3 10^2 10^1 10^0 10^{-1}

MF

G1 K1 M2 S2

95%

(CM/SEC)**2 PER CPH

KINETIC ENERGY SPECTRUM

Z2-6538

1018 M

6/17/83- 7/27/83

(967 HR)

EAST-WEST CURRENT

10^{-3}

10^{-4}

10^{-3}

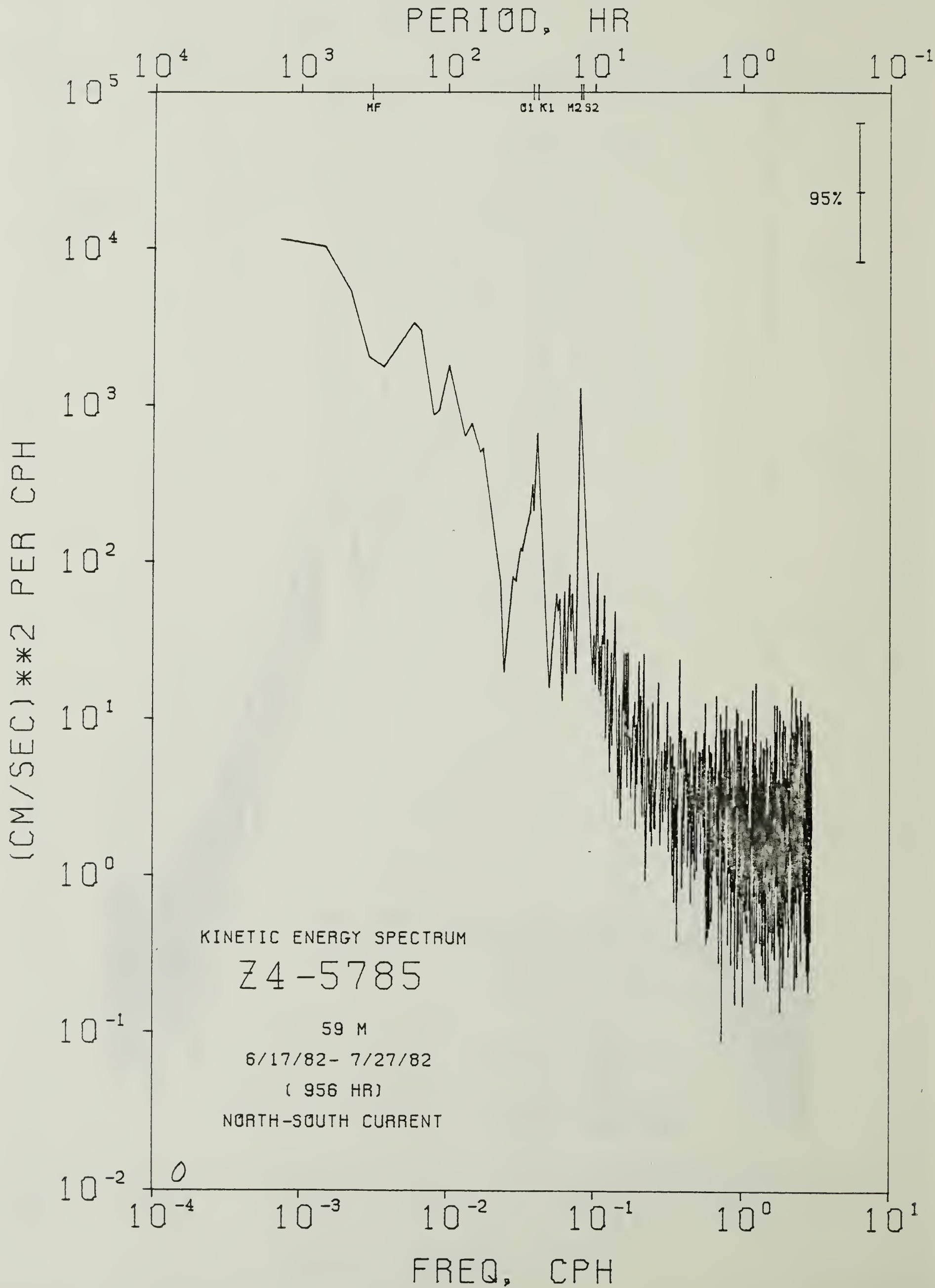
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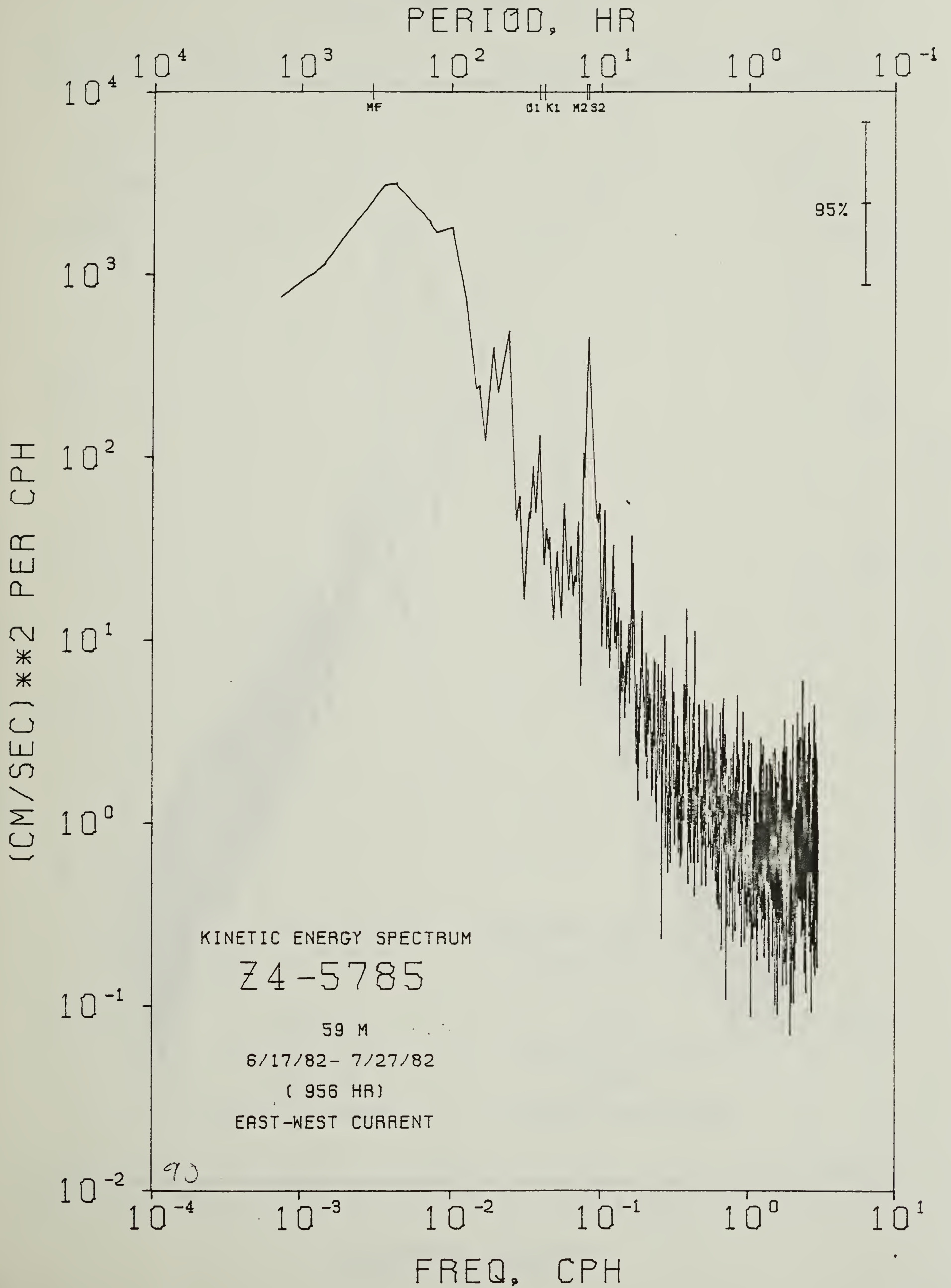
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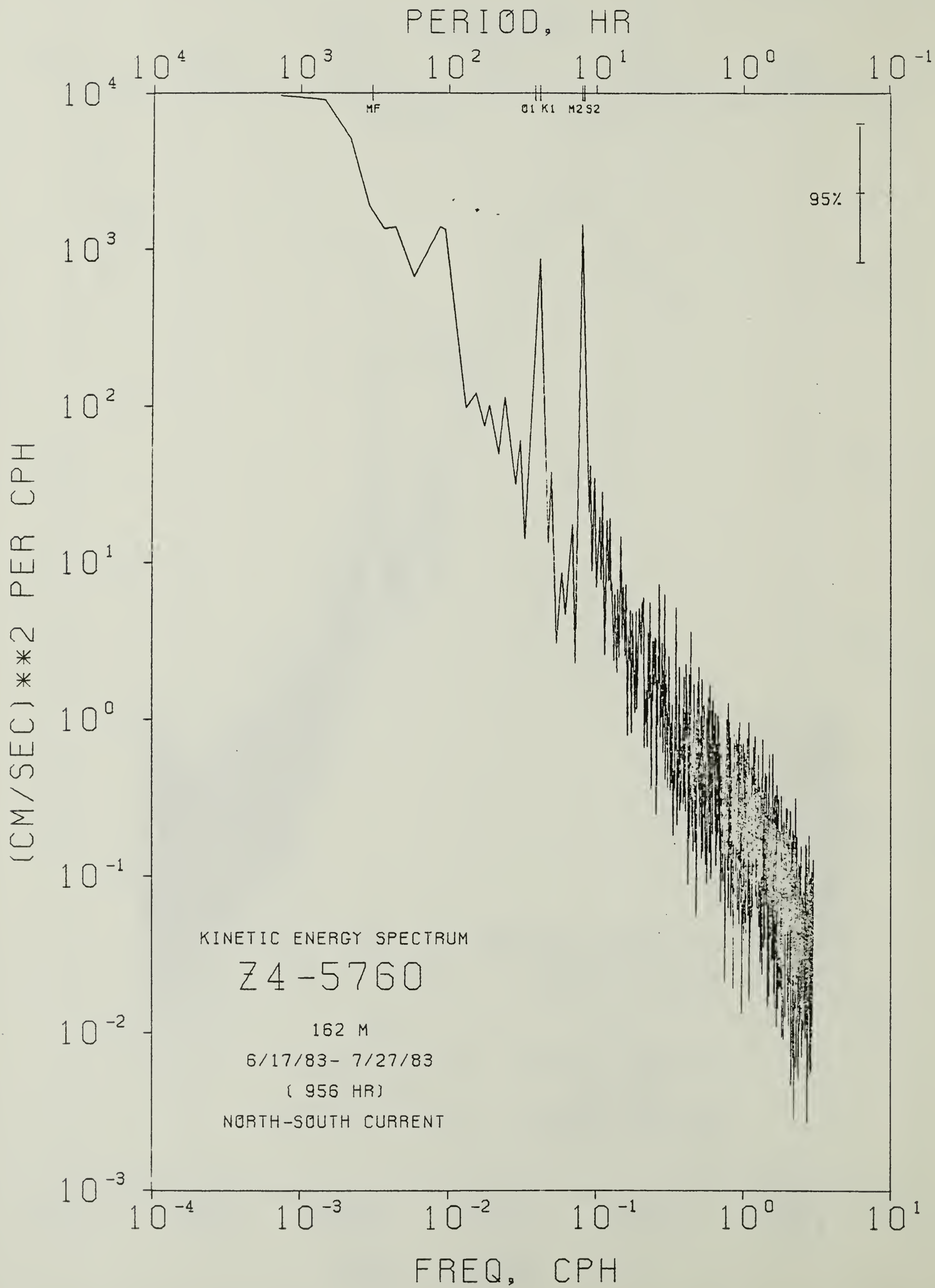
10^0

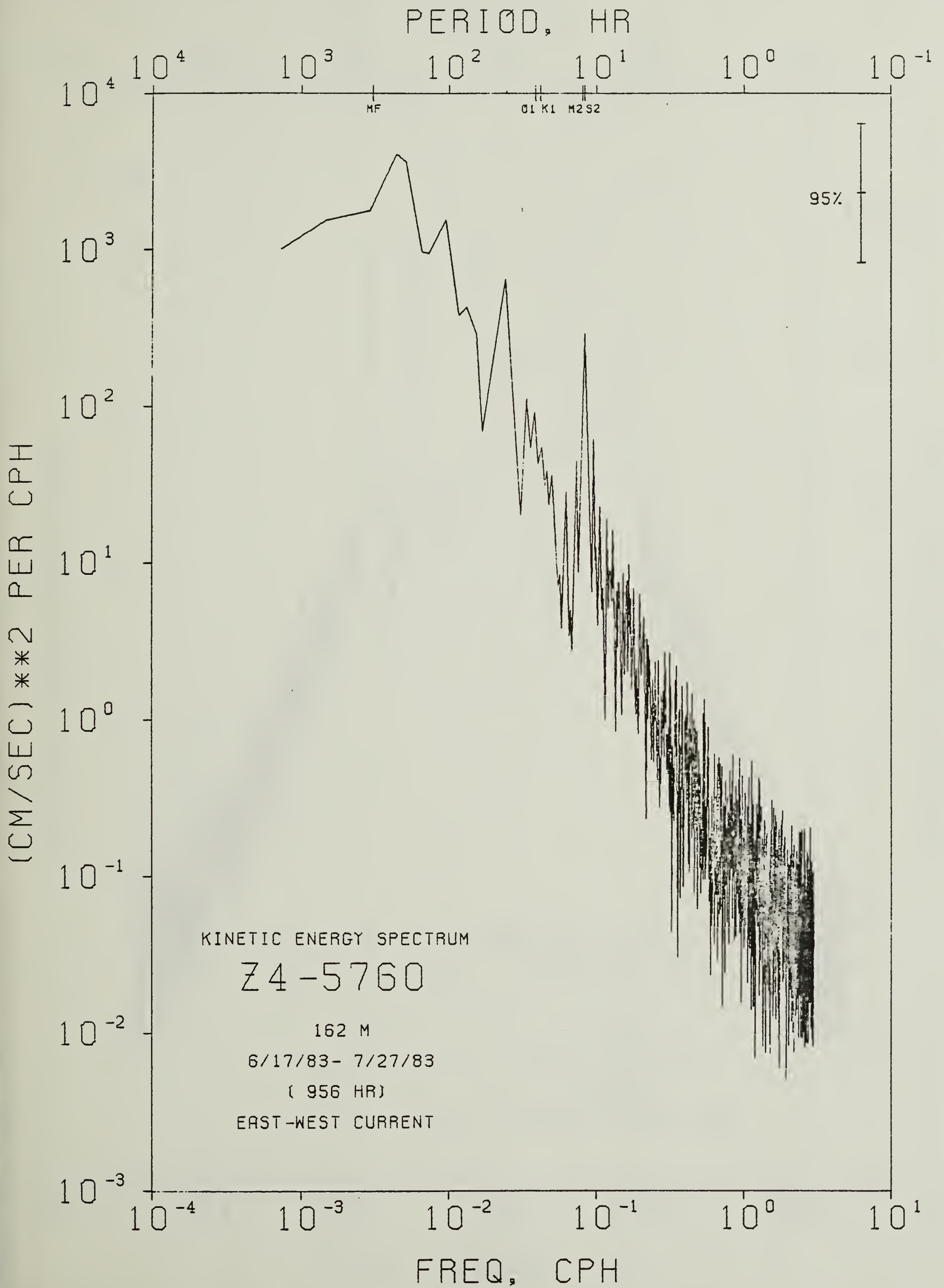
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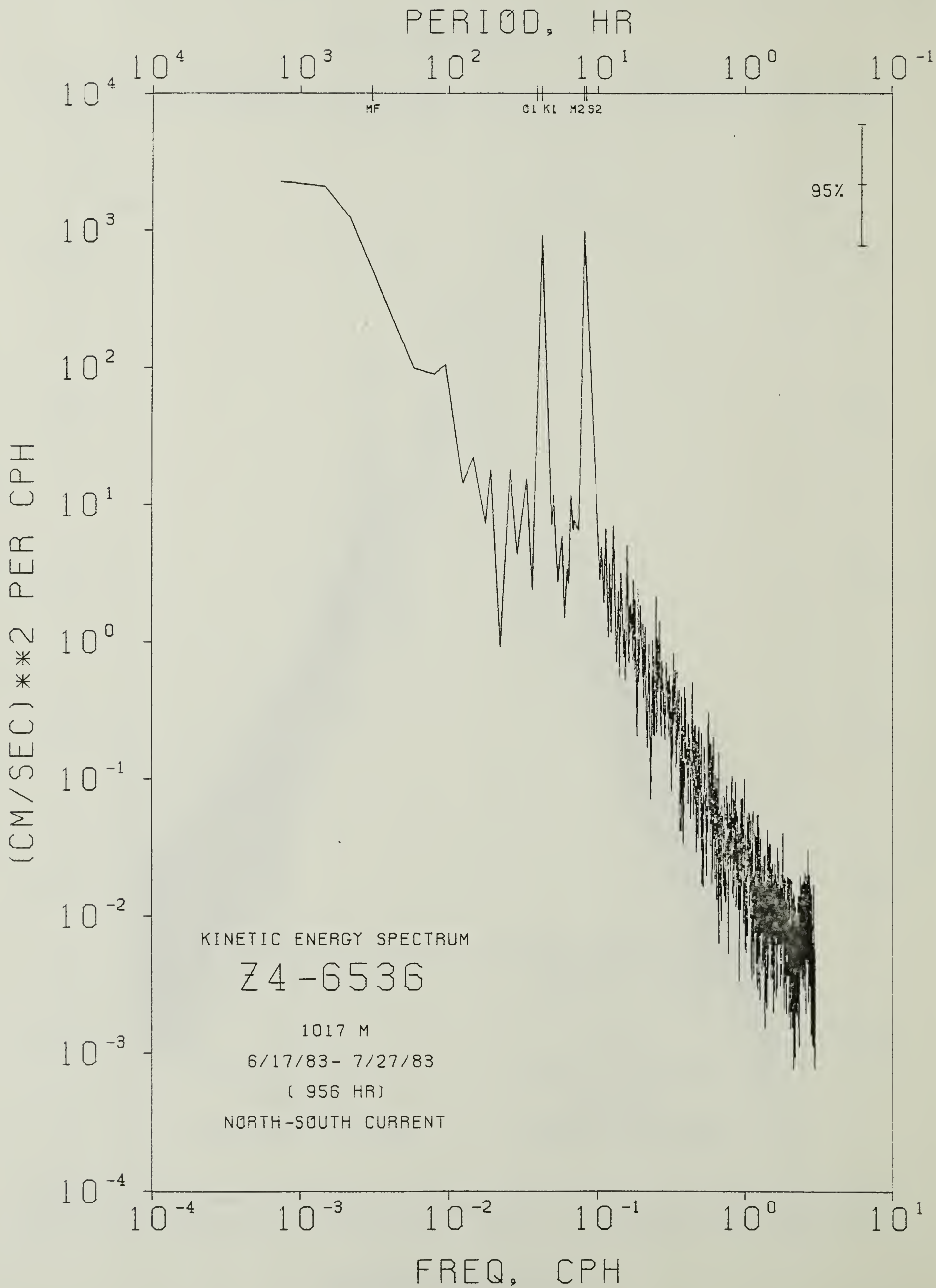
FREQ, CPH

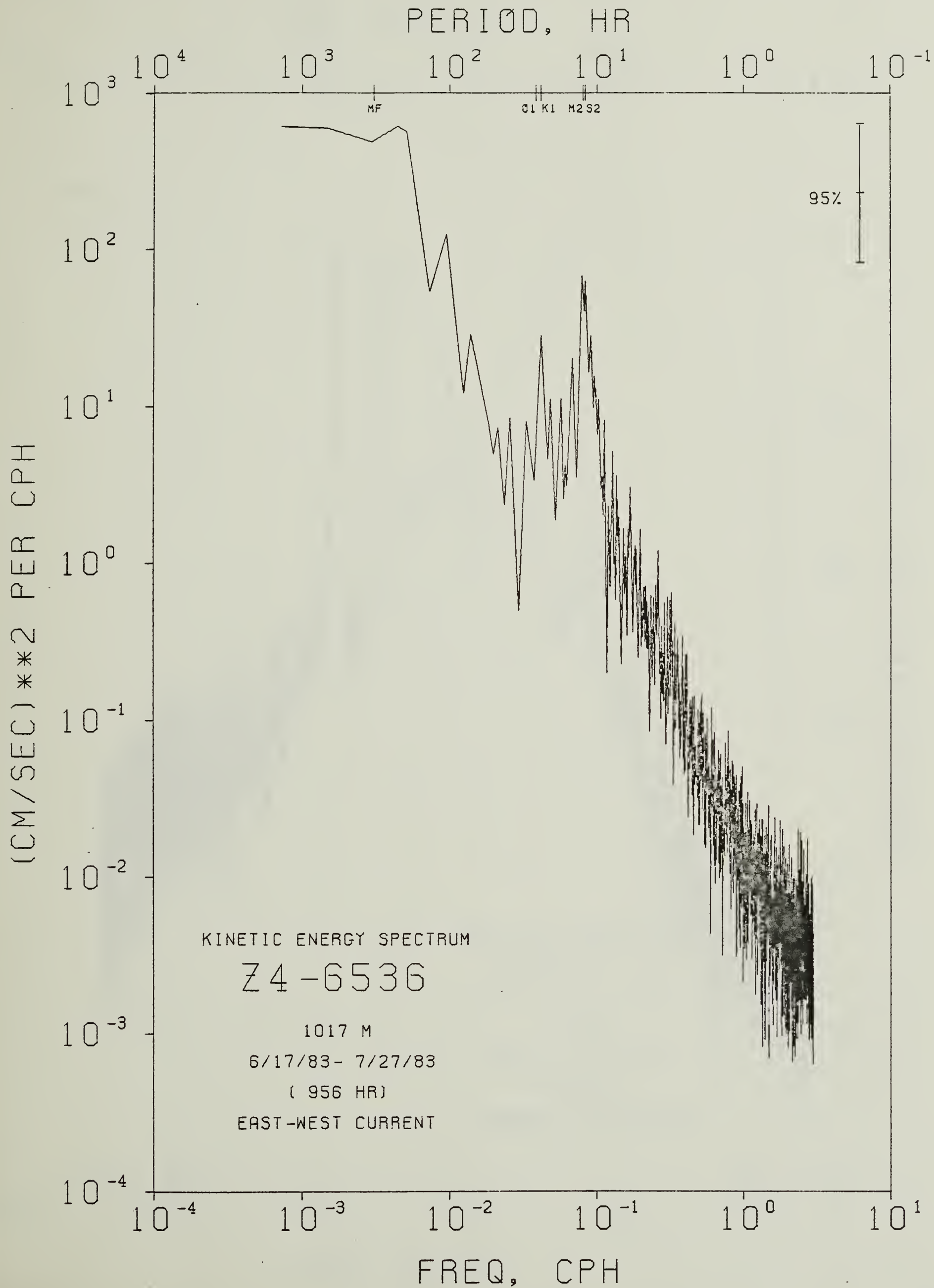


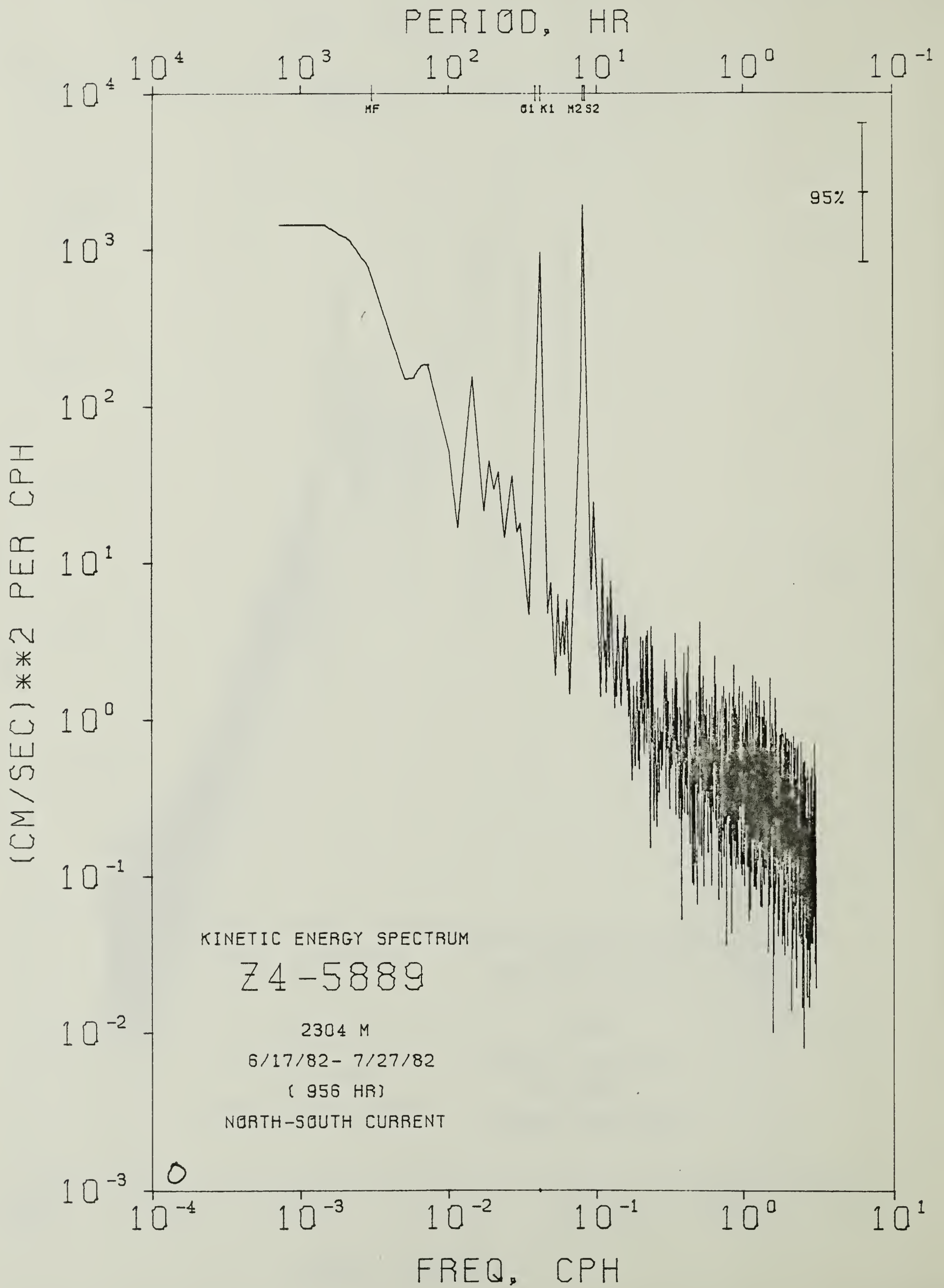












PERIOD, HR

10^4 10^3 10^2 10^1 10^0 10^{-1}

MF

G1 K1 M2 S2

95%

(CM/SEC)**2 PER CPH

KINETIC ENERGY SPECTRUM

Z4-5889

2304 M

6/17/82- 7/27/82

(956 HR)

EAST-WEST CURRENT

90

10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^0 10^1

FREQ, CPH

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